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(WITH TEN PLATES)

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ECHINOIDS FROM THE MIDDLE EOCENE LAKE CITY FORMATION OF GEORGIA

By PORTER M. KIER

U. S. National Museum
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(With Ten Plates)

ABSTRACT

A new echinoid fauna is recorded from a test well in Georgia from an interval identified as the middle Eocene Lake City Formation. Three of the six species are unique: *Leniechinus herricki* Kier, new genus and species, *Echinocyamus bisexus* Kier, new species, and *Pentedium curator* Kier. The fauna is unusual in its display of sexual dimorphism, a character rarely seen in fossil echinoids. One of the species has a brood pouch, and another has females with large genital pores. Presumably these species had large yolky eggs, their young not passing through a pelagic larval stage. The environment probably lacked sufficient plankton for food for the larvae, as in the Antarctic today where sexual dimorphism is common, or a predator was present which fed on the larvae.

INTRODUCTION

A remarkable echinoid fauna was recovered from strata in a test well of the U.S. Geological Survey in Georgia. The specimens came from an interval identified as the middle Eocene Lake City Formation. No echinoids have been collected previously from this formation and very few from any beds of this age in the United States.

Six species are present, all of which are clypeasteroids. Three of the species have not been found elsewhere, and two of them belong to genera not known from any other locality (one of which I described in an earlier paper). The fauna is also unusual in its display of sexual dimorphism, a character rarely recognized in fossil echi-

noids. One of the species has a brood pouch in the females, and another has females with very large, well-separated genital pores.

Such display of otherwise unusual sexual dimorphism suggests that the environmental conditions where these echinoids lived were unusual. Ordinarily, the test of a female echinoid cannot be distinguished from that of a male. Females of most species produce many small eggs which pass through a development that usually includes a free larval stage. The presence, however, of large genital pores in the females in two of the species from the test well indicates that these two species had large yolky eggs. In modern echinoids of this type the females lay very few eggs, and the young do not pass through a free-living stage. Sexual dimorphism and a lack of a free-living larval stage are common in modern Antarctic echinoids. According to Thorson (1950, p. 25), this lack of pelagic larvae is due to lack of food for the larvae. Although the Antarctic seas are well known to have a rich supply of plankton, this production occurs at the surface of the open ocean, whereas the echinoids live either on the shallow water shelves of the Antarctic coasts, where little plankton is available (and then only for a short period), or in the deep sea far from the producing surface layer. Accordingly, nonpelagic development is dominant. As pointed out by Thorson, the greater the size of the individual born, the smaller its relative food requirement and the better its chance of competing under poor food conditions. Although there is no evidence that the seas were cold during the middle Eocene in the Georgia region, perhaps there was a lack of appropriate phytoplanktonic life for other reasons.

Fell, on the other hand (1967, personal communication), suggests that the presence of the large yolky egg in this middle Eocene fauna may indicate that the echinoids lived in an isolated area in which the population dynamics and, in particular, predator relationships did not conform to a continental pattern. He suggests that because all stocks are liable to random mutation, one mutation likely to recur is viviparity or yolkiness in eggs. The presence of a predator of the larvae would ensure the local evolution of a fauna with a high incidence of large yolky eggs or viviparity.

THE ECHINOID FAUNA

The echinoid fauna includes the following species:

Leniechinus herricki Kier, new genus and species
Echinocyamus bisexus Kier, new species
Fibularia alabamensis Cooke
Durhamella cf. *D. floridana* (Twitchell)

Pentedium curator Kier
Periarchus species

It is probable that only part of the echinoid fauna has been recovered, as indicated by the presence almost exclusively of clypeasteroids, and only of species having small tests. No large specimens were collected intact because the material came from drill cuttings. Although fragments of larger specimens of clypeasteroids and a few nonclypeasteroids were collected, they could not be identified.

AGE

According to Herrick, the echinoids were all found in the interval assigned to the Lake City Formation in the U.S. Geological Survey test well number 5, at locality 34H337, near Brunswick, Glynn County, Georgia. The middle Eocene Avon Park Formation occurs above the Lake City in the well, and the lower Eocene Oldsmar Limestone is below.

The age of the Lake City Limestone has been determined as middle Eocene on the basis of the foraminiferal fauna (see Vernon, 1951, p. 90). Because most of the echinoids are new, they are of little use in age determination. The only species known from elsewhere is *Fibularia alabamensis* Cooke, which (according to Cooke, 1959, p. 31) is probably from the early late Eocene Moody's Branch Formation. One specimen is similar to *Periarchus lyelli* (Conrad), a species known from the middle Eocene, and one species is similar to *Durhamella floridana* (Twitchell) from the late Eocene Ocala Limestone.

ACKNOWLEDGMENTS

S. M. Herrick of the United States Geological Survey spent much time studying the rest of the fauna from the test well and determined that the interval producing the echinoids was the Lake City Formation. The echinoids were picked by Robert L. Wait from well samples and were forwarded to me by Harlan B. Counts, both of the U.S. Geological Survey. J. Wyatt Durham and Richard E. Grant read the manuscript and made many useful suggestions, and Barry Fell suggested possible reasons for the sexual dimorphism. J. Roger very kindly lent me specimens from the Laboratoire de Paléontologie, Institut de Géologie, Université de Paris, at Orsay. Thomas F. Phelan took the photographs and made some of the preparations. I am grateful to all of these men for their valuable assistance.

SYSTEMATIC DESCRIPTIONS

Order CLYPEASTEROIDA A. Agassiz
Suborder LAGANINA Mortensen

Family FIBULARIIDAE Gray

LENIECHINUS, Kier, new genus

Type species.—Leniechinus herricki Kier, new species.

GENERIC DESCRIPTION

The test is flattened, elongated, and the apical system is monobasal with four genital pores and a single hydropore. The petals are open and have nonconjugate oblique pores and simple plates. The accessory pores are concentrated along the transverse sutures of the ambulacra beyond the petals, except in the basicoronal ambulacral plates where they occur along the midlength of the plates. The interambulacra terminate at the apical system and originate at the peristome in a single plate. The first coronal plates are larger than most of the plates adapical to them, and the peristome is surrounded by a nodular flange, with the buccal pores occurring within this flange. The periproct is inframarginal, near the posterior margin between the first and second pair of coronal plates. Five pairs of radial interior supports are present, one pair in each interambulacrum. The apophyses are interambulacral in origin. Large, deeply scrobiculate tubercles are present adorally along the lateral margin of the test. The area surrounded by these tubercles is granular.

Remarks.—Leniechinus can be assigned with little doubt to the Fibulariidae. It shares with other genera of this family its nonconjugate pores, absence of food grooves, presence of radial partitions, four genital pores, and small size. The arrangement of the accessory pores is similar to that found in most fibularids, with the pores concentrated along the transverse sutures of the ambulacra beyond the petals, except in the basicoronal ambulacral plates where they are along the midlength of the plates. The flange around the peristome is found in at least three other fibularid genera: *Cyamidia, Lenita,* and *Lenicyamidia.* The large adoral tubercles are also found in *Lenicyamidia* and *Lenita* and are unknown in any other clypeasteroid family. The first coronal plates in *Leniechinus* are more enlarged than typical in the fibularids, but this difference does not seem to warrant familial separation.

Among the fibularids, *Leniechinus* is most similar to *Lenita* in

having a median granular zone, large adoral tubercles, a flange around the peristome, and radial partitions, but differs in having an inframarginal periproct situated between the first and second pair of adoral coronal interambulacral plates. Cotteau (1892, pl. 293, fig. 5) shows no enlargement of the adoral coronal plates in *Lenita patellaris* (Leske), the type species, and shows many small plates in interambulacrum 5. This arrangement seemed so atypical that I borrowed specimens from the Michelin collection, now housed in the Laboratoire de Paléontologie, Institut de Géologie, Université de Paris at Orsay, in order to check this feature. Although the plate sutures were difficult to see, staining revealed some of the sutures in interambulacrum 5, showing that Cotteau's figure is inaccurate and that the first coronal plates in the interambulacra and ambulacra are enlarged (Figure 4). Photographs of one of these specimens are on plate 1, figures 1, 2. Although the peristome is larger and more central in this specimen than in some of the specimens figured by Cotteau, this difference is due to the smaller size of the specimen. Cotteau's largest figured specimen was 17 mm long, whereas the specimen figured herein is only 5.0 mm. Cotteau illustrates several smaller specimens which show this more central peristome.

Leniechinus is similar to *Lenicyamidia* in adorally having a median granulate area surrounded by large, deeply scrobicule tubercles, in having its periproct in approximately the same position, and in having a flange around the peristome. It differs from *Lenicyamidia* in having well-developed internal partitions which are lacking entirely in *Lenicyamidia.* Although Brunnschweiler (1962, p. 167) stated that the apical system in *Lenicyamidia* was composed of four genital plates and a central madreporic plate, Philip (1966, p. 116) has reexamined the types and found it to be monobasal as typical in the clypeasteroids.

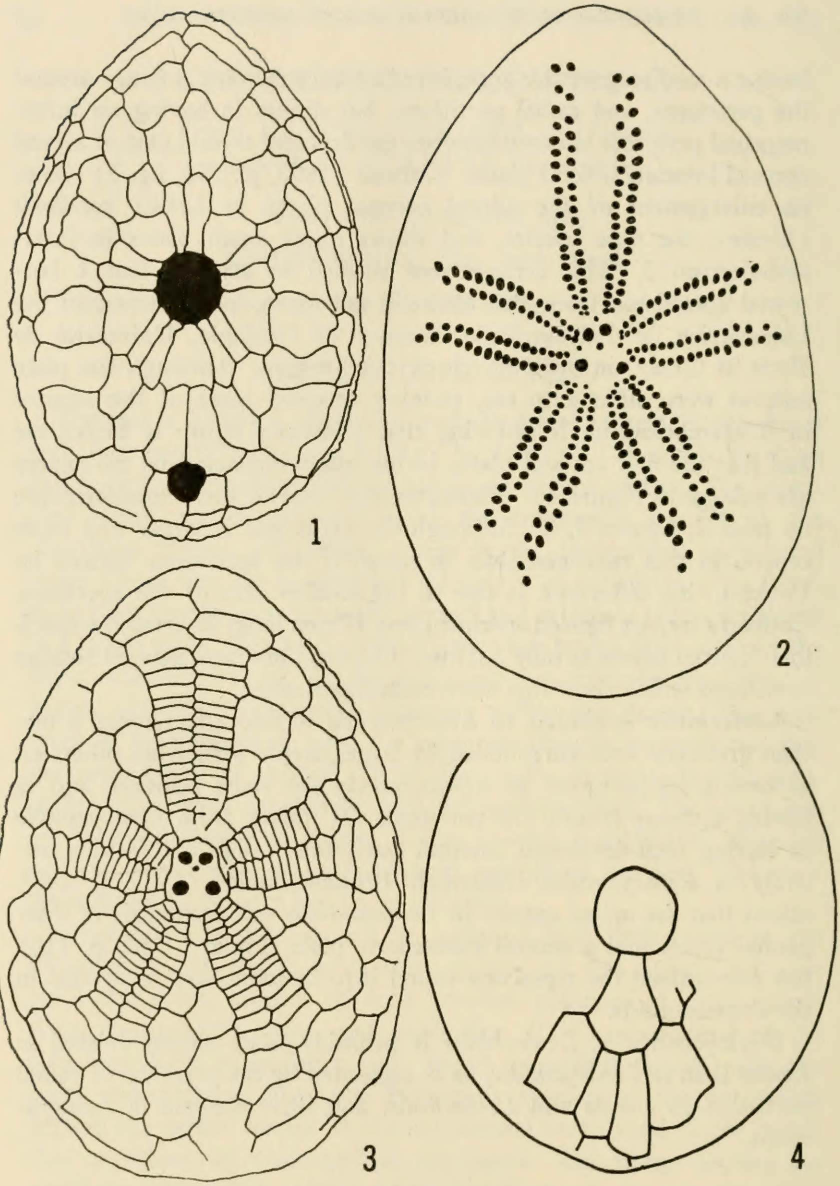
Phylogenetically, *Leniechinus* is probably more closely related to *Lenita* than to *Lenicyamidia,* as is suggested by the presence of radial partitions in *Lenita* and *Leniechinus* and their absence in *Lenicyamidia.*

LENIECHINUS HERRICKI Kier, new species

Plate 1, figures 3, 4; Plate 2, figures 1-5; Figures 1-3, 5-10

Material.—Sixteen specimens.

Shape and size.—The specimens vary in length from 3.9 to 21.0 mm. The test is narrow, the width (Figure 5) from 60 to 70 percent of the length, with the greatest width posterior to the center. The



FIGURES 1-4.—1-3, *Leniechinus herricki* Kier, new species. 1, Adoral view of USNM 650749 from the test well level 1135-1160 feet showing the plate arrangement; $\times$ 10. 2, Adapical view of the holotype, USNM 650717, from the test well 1135 feet; $\times$ 10. 3, Adapical view of USNM 650750 showing the plate arrangement; $\times$ 10. 4, *Lenita patellaris* (Leske). Adoral view showing plate arrangement, where visible, of a specimen from the middle Eocene, Parney, France, from the Michelin collection, Laboratoire de Paléontologie, Institut de Géologie, Université de Paris, Orsay; $\times$ 15.

anterior margin is pointed, the posterior blunted. The test is low, with a height varying from 20 to 23 percent of the length (Figure 6). The greatest height is central at the apical system. The margin is thin, and the adoral surface flat to slightly depressed.

Apical system.—The system is central, or slightly posterior or anterior, and has four genital pores. No genital pores are present in the smallest specimen, 3.9 mm long, but all are present in the longest, 4.7 mm long. A specimen 5.5 mm long has only the left anterior pore, and in a specimen 7.6 mm long the two anterior pores

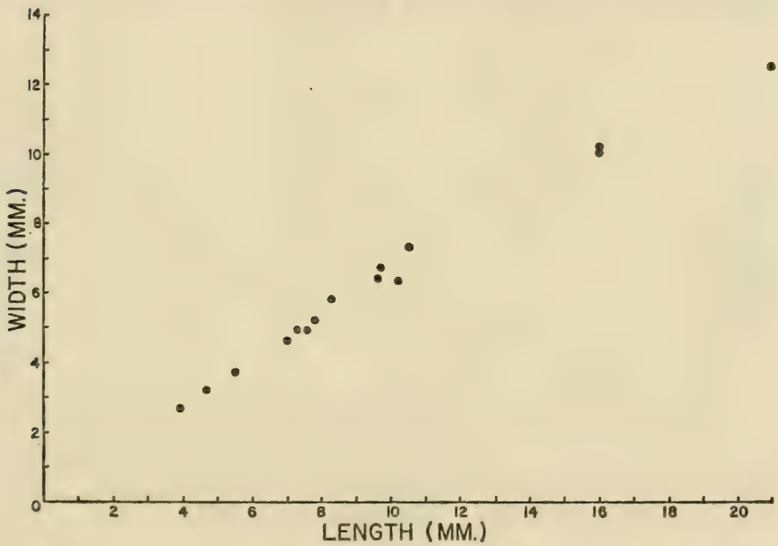


FIGURE 5.—*Leniechinus herricki* Kier, new species. Scattergram of the length and width showing the slight variation in the length-width ratio.

are fully developed, but the two posterior pores are very small. Evidently the anterior pores are introduced first in this species. All the genital pores are present in specimens larger than 7 mm. The anterior pores are closer together than the posterior. The pores are within the fused genital plates in most of the specimens, although the two posterior pores may be on the edge on several of the specimens in which the pores are more widely separated from each other, but the plate sutures are not clear enough to be certain.

The genital pores are much larger and more widely separated from each other on some of the specimens. This difference may be sexually dimorphic, but scattergrams of the width of the genital pores

and the distance between the pores (Figures 7, 8) show no marked separation of the points into two paths.

A single hydropore is present.

Ambulacra.—The petals are well developed with II, III, and IV extending 80 percent of the distance from the center of the apical system to the margin, but petals V and I only 60 percent. All the petals are open, but petal III is more widely open. The interporiferous zones at the extremities of the petals are twice as wide as the poriferous zones. The pores are large, not conjugate. The outer pore of a pair is more distal to the inner, and slightly elongated. Petal III has from two to eight (average of five) more pore-pairs

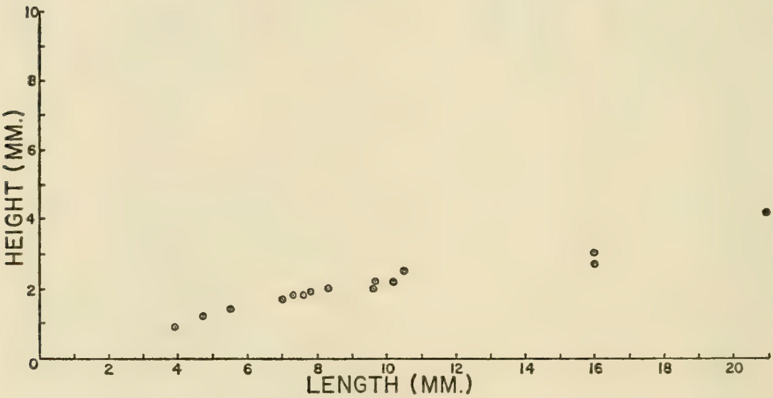


FIGURE. 6.—*Leniechinus herricki* Kier, new species. Scattergram of the length and height.

in a single poriferous zone than petals II or IV, and from zero to five (average of three) more than V or I. As evident from a scattergram (Figure 9), new pore-pairs are introduced at a constant rate until the echinoid is over 10 mm long when the rate appears to decrease, although the sample is too small to be certain. In the smallest specimen, 3.9 mm long, 7 pore-pairs are in a single poriferous zone of petal III, 5 in petal IV, 26 pore-pairs are in petal III, 18 in IV, and 23 in V.

The accessory pores are confined to the ambulacra except for a few in the interambulacra between the petals. Adapically, as many as 20 accessory pores occur in the transverse sutures of the interporiferous zones of a single petal. The pores are common beyond the petals where they are concentrated along the transverse sutures in a continuous line of pores. A few are also in the adradial suture,

but none in the perradial. Adorally, they are more numerous with a double row of pores in the sutures of the first coronal plates. The accessory pores in the basicoronal ambulacral plates do not occur along the sutures, but are in two to three rows running longitudinally along the midlength of each plate, with as many as 45 in a single plate. Buccal pores are present in the basicoronal ambulacral plates at the edge of the peristome.

Adapical interambulacra.—The adapical plate sutures are clearly visible on only USNM 650750. On this specimen (Figure 3), the

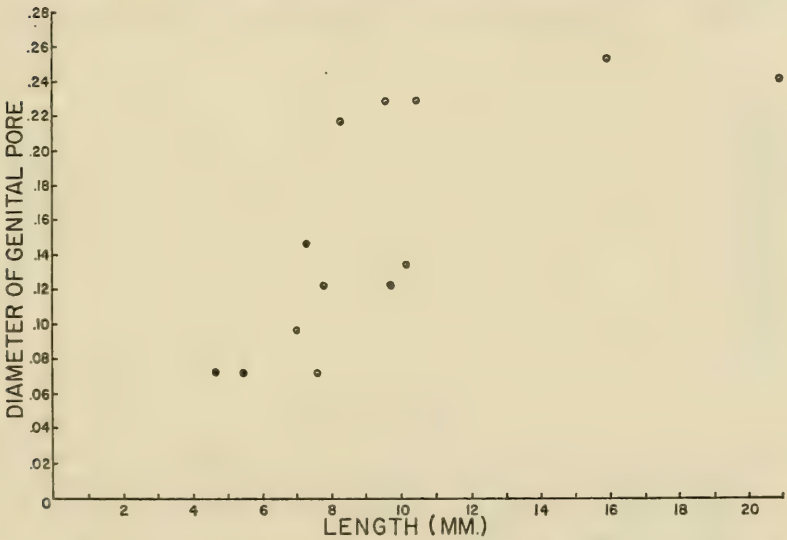


FIGURE 7.—*Leniechinus herricki* Kier, new species. Scattergram showing the great variation in the diameter of the genital pores. The lack of separation of the points into two distinct paths suggests sexual dimorphism.

interambulacra terminate with two single plates in a row in all the areas except interambulacrum 1.

Adoral plate arrangement.—A single plate is present at the peristome in each interambulacrum. Commonly, the basicoronal plates of the anterior interambulacra (2 and 3) are hexagonal, whereas those of the other columns are heptagonal. The basicoronal ambulacral plates are paired in each column and are approximately as high as the adjacent interambulacral plates except for the basicoronal plates of ambulacrum III, which are at least one-third higher than the adjacent initial plates of interambulacra 2 and 3. The first coronal ambulacral plates (Figure 1) are considerably larger than the basi-

coronal ambulacral plates. The second coronal ambulacral plates in ambulacrum III are approximately the same size as the first, but have their greatest length transverse rather than longitudinal. In ambulacra II and IV, the second coronal ambulacral plates are much smaller than the first and not different in size from the rest of the ambulacral plates adapical to them. In ambulacra V and I, the second coronal ambulacral plates are larger than the first and have their greatest length transverse to the ambulacra. The first three coronal interambulacral plates in interambulacra 2 and 3 are larger than the plate adapical to them, whereas in columns 4 and 1 only the first two plates are larger. In interambulacrum 5, the first 2 coronal plates are

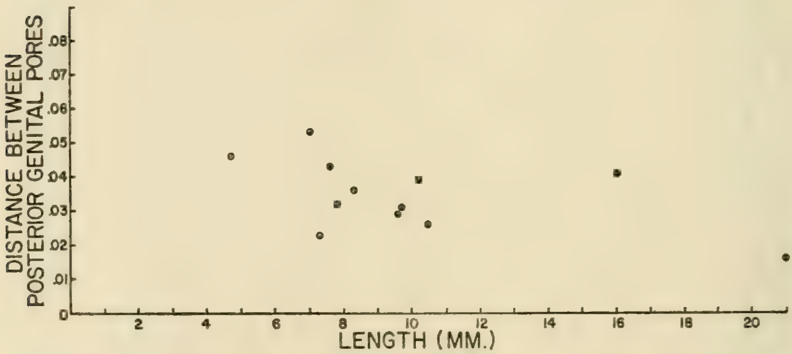


FIGURE 8.—*Leniechinus herricki* Kier, new species. Scattergram showing the great variation in the distance between the genital pores. The lack of a distinct separation of the points into two paths suggests that this variation is not due to sexual dimorphism.

approximately twice as large as the two adapical to them, which are in turn almost twice as large as the plates adapical to them.

Peristome.—The opening is central and slightly elongated longitudinally. It is smaller relative to the length of the test in the larger specimens than in the small (Figure 10). In a specimen 16 mm long, the peristome is only 8.6 percent as high as the length of the test, whereas in the smallest specimen, 3.9 mm long, the peristome is 19 percent as high as the length of the test. A roughly pentagonal noded ridge (pl. 2, fig. 2) surrounds the peristome. This pentagon is pointed posteriorly, blunted anteriorly, with slight lobes extending into the interambulacra. The buccal pores (but no accessory pores) occur within this flange. That part of the test within this flange dips sharply down to the peristomal opening.

Periproct.—The opening is slightly elongated longitudinally and is inframarginal, located near the posterior margin and separated

from this margin by a distance equal to, or less than, the height of the opening. In a specimen 10.2 mm long, the periproct is 0.66 mm at its greatest diameter, and the posterior edge of the opening is 0.47 mm from the posterior margin of the test. The periproct is between the first and second pair of coronal plates.

Interior supports.—The supports are radial (pl. 2, fig. 5).

Lantern and supports.—No lantern is visible on any of the specimens, and not enough specimens are available to permit dissection. The supports are interradial in position and are interambulacral in

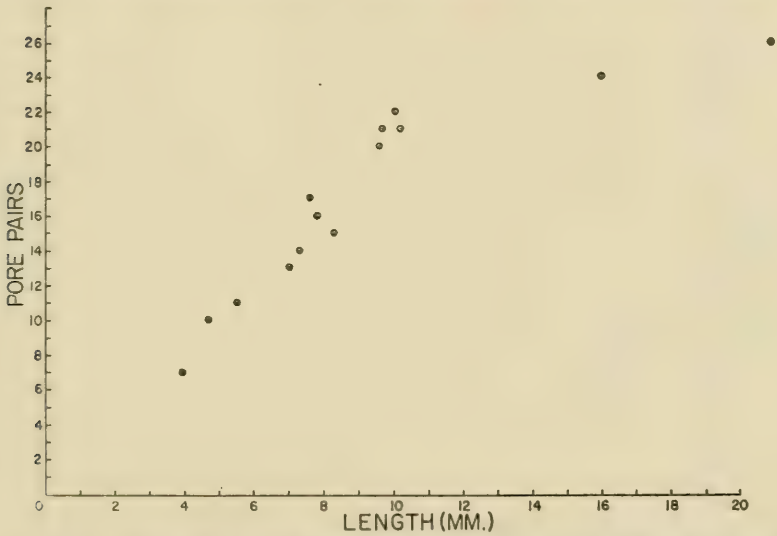


FIGURE 9.—*Leniechinus herricki* Kier, new species. Scattergram showing the number of pore-pairs in a single poriferous zone of petal III. As evident from the curve in the path of the points, new pore-pairs are introduced at a slower rate after the echinoid exceeds 10 mm in length.

origin. Each is highest in its middle and has a slight ridge extending down the middle of the front face with a depression on each side.

Tuberculation.—Approximately twenty extraordinarily large tubercles are present on the adoral surface (pl. 1, fig. 4) near the lateral margins of the test. Their scrobicules are very depressed and are more enlarged posteriorly. The bosses rise to the general height of the test, but in none of the specimens are they preserved well enough to show whether they were crenulated or whether their mamelons were perforated. These tubercles resemble those found on the adoral surface of some of the spatangoids, such as *Lovenia* and *Breynia,* and probably supported similar long, curved spines. Both Clark (1938, p. 440) and Mortensen (1951, p. 102) observed

that in *Lovenia elongata* (Gray) the echinoid raised itself up on these spines and walked on and with them at great speed. The fact that the scrobicules in *Leniechinus herricki* are larger posteriorly indicates that the muscles were larger there and that the spines would be able to exert their greatest force posteriorly.

Types.—Holotype USNM 650717, figured paratypes USNM 650718, 650719, 650750.

Intervals in test well.—1130-1135 feet, 1135 feet, 1135-1145 feet, and 1135-1160 feet.

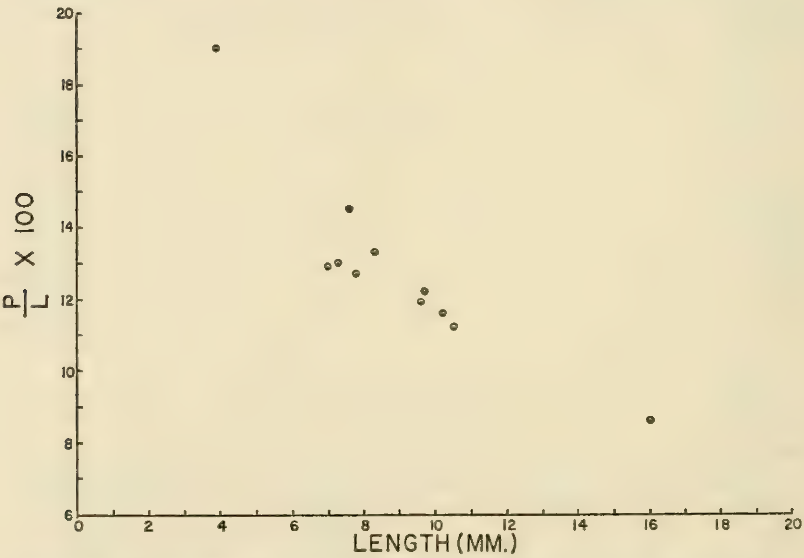


FIGURE 10.—*Leniechinus herricki* Kier, new species. Scattergram showing the percentage relation of the size of the peristome to the length of the test. **P** equals the diameter of the peristome. Note that the peristome is larger relative to the test in the smaller specimens.

Genus ECHINOCYAMUS van Phelsum

ECHINOCYAMUS BISEXUS Kier, new species

Plate 3, figures 1-6; Plate 4, figures 1, 2; Figures 11-23

Material.—Eleven females, seven males.

Shape and size.—The specimens vary in length from 1.52 to 7.2 mm. The test is narrow, with the width (Figure 11) averaging 67 percent of the length, although in the two smallest specimens, 2.9 and 1.52 mm long, the width is greater, 72 and 75 percent of the length respectively. The greatest width is posterior to the center.

The anterior margin is pointed, the posterior more rounded. The test is low, with a height averaging 38 percent of the length and varying from 31 to 46 percent (Figure 12). The greatest height is posterior to the center, and the adapical surface is smoothly rounded, the adoral flattened.

Apical system.—The system is slightly anterior of center and has four genital pores. The ocular pores are small and occur on the fused genital plates which are pierced by a single hydropore. The

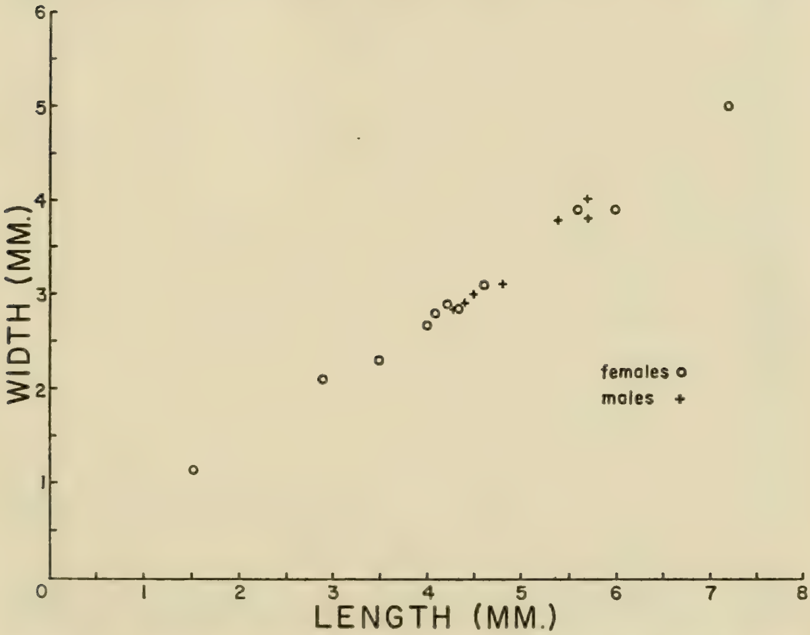


FIGURE 11.—*Echinocyamus bisexus* Kier, new species. Scattergram showing the length to width ratio and the lack of difference in this character in specimens considered to be males or females.

genital pores in eleven of the specimens (herein considered to be females) are large, 1 mm in diameter in a specimen 6 mm long, and widely separated from each other. The anterior pores are closer together than the posterior and occur on the edge of the fused genital plates on the smaller specimens, but within the first interambulacral plate on the larger. The posterior pores are far out in the interambulacral, but still within the first interambulacral plate or at its adoral suture with the adoral interambulacral plates. In seven of the specimens, presumably males, the genital pores are much smaller and

situated much closer together. The anterior pores are closer together than the posterior, and all the pores are within the fused genital plates.

Ambulacra.—The petals are long, extending two-thirds the distance from the apical system to the margin of the test. The anterior petal (Figures 13, 14) is open, whereas the others are slightly closed. The interporiferous zones are slightly wider than the poriferous. The pores are large, round, not conjugate, with the outer pore of a pair more distal to the inner. The anterior petal (III) and the posterior petals (V and I) have approximately the same number of pore-pairs,

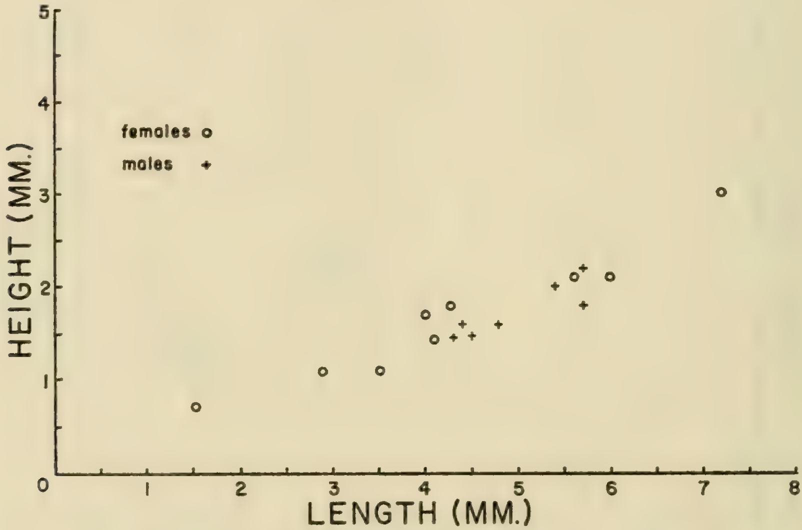


FIGURE 12.—*Echinocyamus bisexus* Kier, new species. Scattergram showing the length to height ratio and the lack of difference in this character in specimens considered to be male or female.

but petals II and IV have one to three fewer pore-pairs in each poriferous zone. A specimen 7.2. mm long has ten pore-pairs in petals III, V, and I, and eight in II or IV (see Figure 12 for number of pore-pairs in petals III and IV in all specimens).

The accessory pores are confined to the ambulacra except for several in the interambulacra between the petals. Adapically, a few (as many as three seen) are present in the interporiferous zone, but they are much more common beyond the petals where they are concentrated along the transverse sutures in a line of pores, with as many as 15 along a single suture. A few also occur along the adradial suture, but none are present in the perradial suture. The accessory

pores in the basicoronal ambulacral plates (Figure 21) do not occur along the sutures, but are in two rows running longitudinally along the midlength of each plate, with as many as 15 pores in each plate. Buccal pores are present in the basicoronal ambulacral plates at the edge of the peristome.

Adapical interambulacra.—Although the adapical plate sutures are difficult to see, a few are visible in some specimens. On USNM 650746, the anterior paired interambulacra terminate at the apical system, with at least two single plates in a row in each interambulacrum. There may be a third small plate at the apical system, but it is not possible to be certain. There appears to be only one single plate terminating each of the other columns. In one of the smallest specimens (USNM 650748), two plates terminate interambulacra 3, but only one is present in all the others.

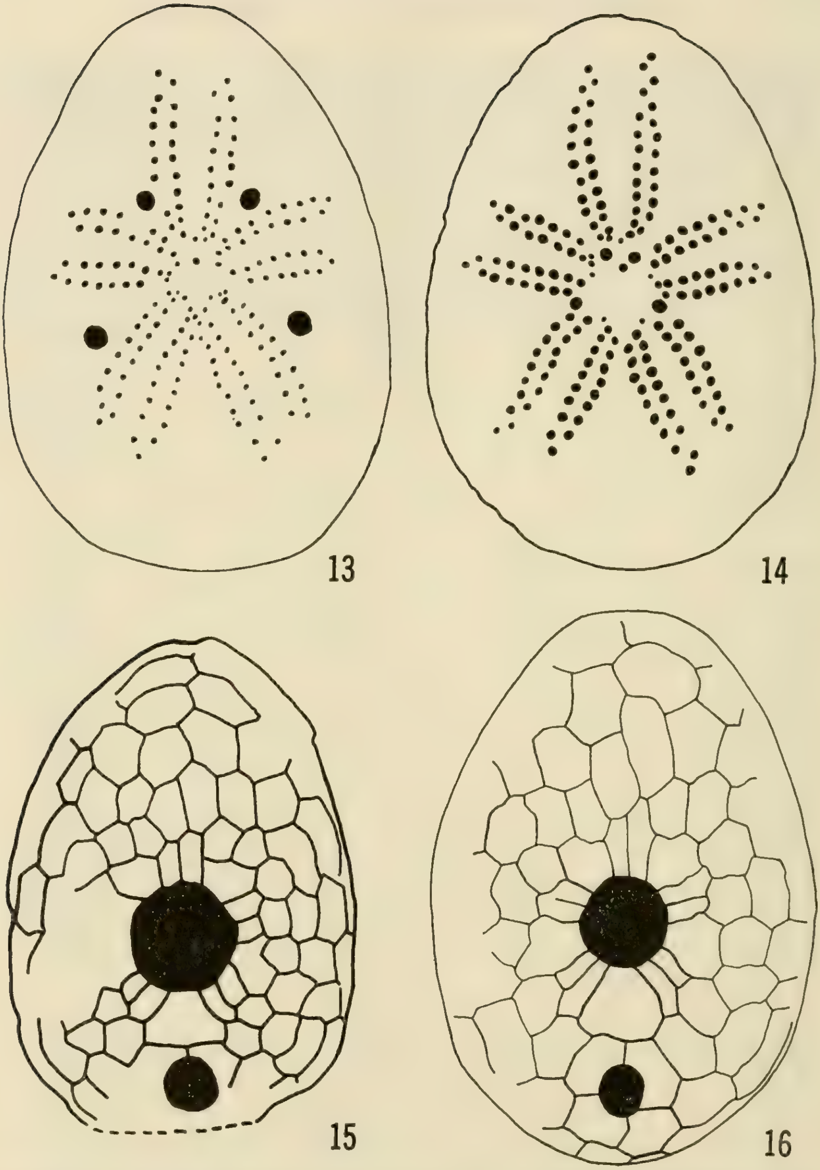
Adoral plate arrangement.—The basicoronal plates (Figures 15, 16) are not arranged in a star or pentagon. A single plate is present at the peristome in each interambulacrum. The posterior basicoronal interambulacral plate is the largest. Commonly, the basicoronal plates of the anterior interambulacra (2 and 3) are hexagonal, whereas those of the other columns are heptagonal. The basicoronal ambulacral plates are paired in each column and are lower than the adjacent interambulacral plates except for basicoronal ambulacral plate IIIb, which is higher than the basicoronal interambulacral plate of column 2. The first coronal ambulacral plates (Figure 16) are not larger than the ambulacral plates adapical to them, although in ambulacra III, V, and I they are of a different shape, with their greatest length longitudinal rather than transverse as in the plates adapical to them. The first coronal interambulacral plates are not larger than the plates adapical to them in the same column.

Peristome.—The peristome is slightly posterior to the center, and circular to slightly pentagonal (Figure 16), with a diameter in the larger specimen equal to 15 percent of the length of the test, 25 to 30 percent in the smaller specimens (Figure 18).

Periproct.—The opening is inframarginal, located approximately two-thirds the distance from the peristome to the posterior margin, between the first and second pair of coronal plates. The opening is circular and large, with a diameter of between 7 to 10 percent of the length of the test.

Internal supports.—The supports are radial, with a pair in each interambulacrum (Figure 22).

Lantern and supports.—No lantern is visible on any of the speci-



FIGURES 13-16.—*Echinocyamus bisexus* Kier, new species. 13, Adapical view of USNM 650745 from the test well level 1130-1135 feet showing the large and widely separated genital pores, which suggest that this individual was a female; $\times$ 12. 14, Adapical view of the holotype, USNM 650722, showing the smaller, closely situated genital pores, which suggest that this specimen was a male as opposed to the female in Figure 13; test well level 1130-1135 feet; $\times$ 14. 15, Adoral view of USNM 650748 showing the plate arrangement in a small specimen as contrasted to the larger specimen in Figure 16 (USNM 650746—1135-1160 feet). Note that the first coronal plates are smaller and the peristome larger than in the larger specimen.

mens, and not enough specimens are available to permit dissection. The supports are interradial in position and appear to be interambulacral in origin. Each is highest in its middle and has a slight

FIGURE 17.—*Echinocyamus bisexus* Kier, new species. Scattergram showing the number of pore-pairs in petals III and IV relative to the length of the test in specimens considered to be males and females.

ridge extending down the middle of the front face with a depression on each side.

Growth.—Although only 18 specimens are available, there is considerable range in their size from 1.52 mm to 7.2 mm in length, and

some allometry is evident. The peristome in the smaller specimens (Figure 20) is large relative to the size of the test, and gradually decreases in diameter relative to an increase in the length of the test (Figure 18). Its diameter is 30 percent of the length of the test in the smallest specimens, but only 14 percent in the largest. The change in the relative size of the periproct is less marked, but in the smaller specimens it is somewhat larger, with a diameter equal to 10 percent of the length of the test as compared to 7 to 8 percent in the larger specimens. The periproct on the smallest specimen is located on the margin partially visible from above (Figure 19), but on the next largest specimen, 2.9 mm long, it is inframarginal, but still more

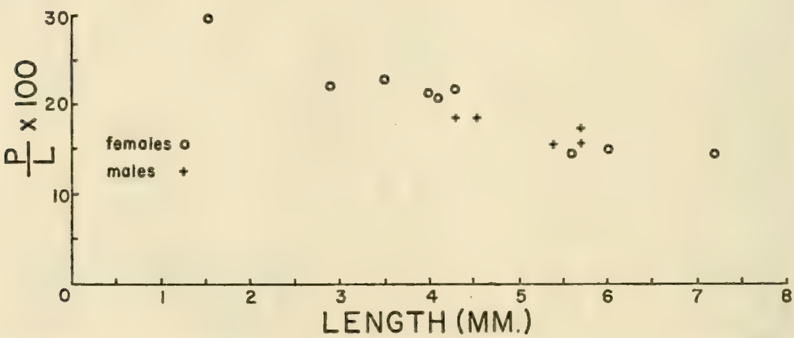
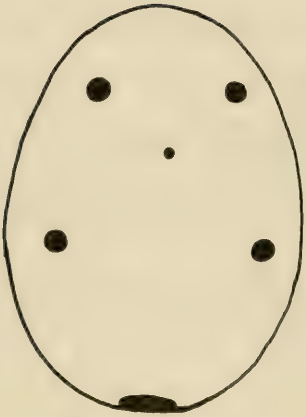


FIGURE 18.—*Echinocyamus bisexus* Kier, new species. Scattergram showing the relation of the size of the peristome to the length of the test. **P** equals the diameter of the peristome.

posterior than in the adults. In all the rest of the specimens it is in its adult position.

The genital pores are present in all the specimens. On the smallest female specimen (Figure 19) they are situated out near the margin of the test, and although the pores do become farther separated as the test grows (Figure 23), the test grows at a faster rate so that the pores become more central in their location relative to the margin of the test. Apparently, the pores initially are introduced in the female in the position found in the smallest specimen (Figure 19), although more specimens would be needed in order to be certain. The plot of the distance between the posterior pores on the scattergram (Figure 23) suggests that these pores are never less than 0.5 mm apart.

Pore-pairs are introduced for the petals at a slightly decreasing



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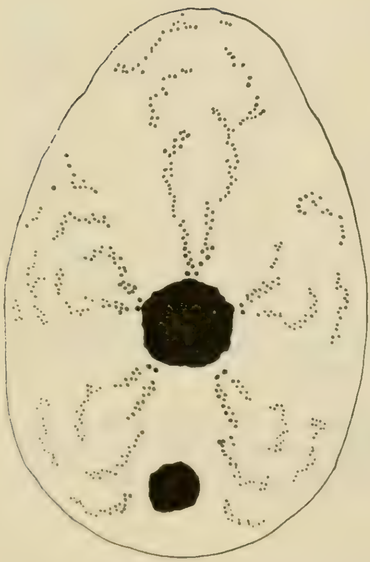

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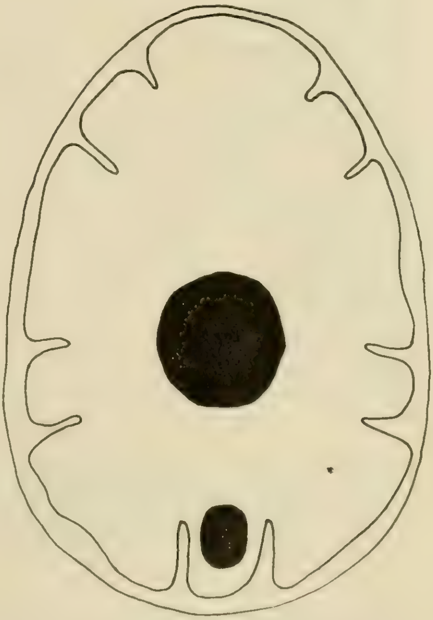

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FIGURES 19-22.—*Echinocyamus bisexus* Kier, new species. 19, Adoral view of smallest specimen in the collection showing the widely separated genital pores. Presumably when the genital pores are first introduced in the female, they are this far apart. Note the periproct partially visible from above; USNM 650721 from the test well level 1130-1135 feet; × 40. 20, Adoral view of same specimen showing the large peristome; × 40. 21, Adoral view of a female specimen, USNM 650723, from the test well level 1135-1145 feet showing the arrangement of the accessory pores; × 14. 22, View of interior of USNM 650747 showing the position of the interior supports; test well level 1130-1135 feet; × 20.

rate throughout the growth of the echinoid, as evident from a scattergram (Figure 17).

Types.—Holotype USNM 650722, figured paratypes USNM 650720, 650721, 650723, 650745, 650747, 650748.

Intervals in test well.—1130-1135 feet, 1135-1145 feet, 1135-1160 feet.

Comparison with other species.—*E. bisexus* most resembles *Echinocyamus parvus* from the Castle Hayne Limestone. Both species

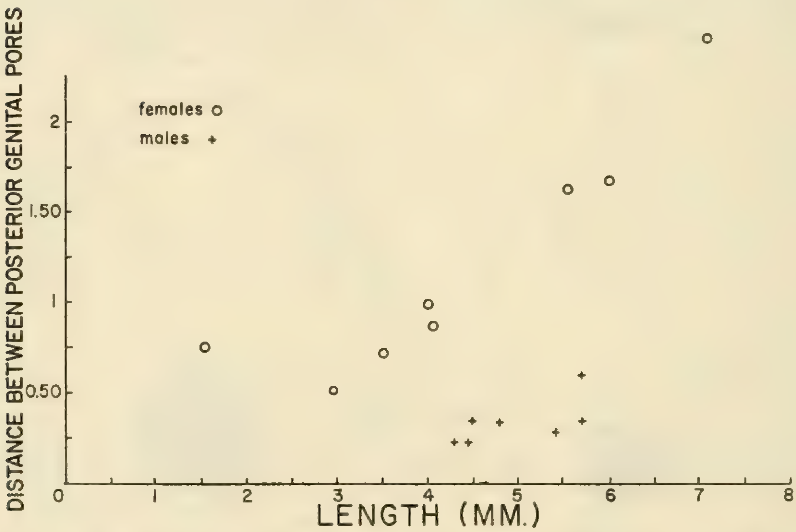


FIGURE 23.—*Echinocyamus bisexus* Kier, new species. Scattergram of the distance between the two posterior genital pores relative to the length of the test. Note the two well-separated paths of points, suggesting sexual dimorphism.

have a similar shape, periproct position, and size of peristome. *E. bisexus* differs in having long petals with more pore-pairs and a smaller fused madreporite.

Sexual dimorphism.—Of the 18 specimens referred to this species, 11 of them have large widely spaced genital pores, and 7 have small, closely spaced pores. No intermediates are present, as is evident in the scattergram of the distance between the posterior pores (Figure 23). In all other characters the two groups of specimens are identical, such as the width (Figure 11) and height (Figure 12), diameter of peristome (Figure 18), distance of the periproct from

the posterior margin, and number of pore-pairs in the petals (Figure 17). There is little doubt that this dimorphism was sexual. Presumably these large genital pores are an indication that the echinoid had large yolky eggs (Mortensen, 1922, p. 147, 151). According to Hyman (1955, p. 505), echinoids which have large eggs have a direct development, with no free larval stage, and metamorphism may occur after two or three days of development instead of the four to six weeks usually required for the more normal development of an echinoid in which the pluteus stage is not omitted. This direct development is common in echinoids that brood their young, but there is no brood pouch in *Echinocyamus bisexus*. Although some echinoids which brood their young do lack a pouch, they commonly have some depression on their test, such as a sunken petal as in the Antarctic spatangoids or a depression around the periproct as in *Hypsiechinus coronatus* Mortensen, in which they keep their young. Some of the cidarids which brood their young lack any sunken area, but their spines are long and by crisscrossing them over the brooding area, they are able to hold their young in place. The presence of only short spines in *E. bisexus,* combined with the lack of any sunken area (the adoral surface is not even depressed around the peristome), suggests that it may have been unable to brood its young on its test. Perhaps the eggs were deposited on the substratum near the parent. According to Hyman (1955, p. 292), some of the sea stars attach their large and yolky eggs to objects, typically the undersurface of stones, and do not remain to protect them.

Genus FIBULARIA Lamarck

FIBULARIA ALABAMENSIS Cooke

Figures 24-26

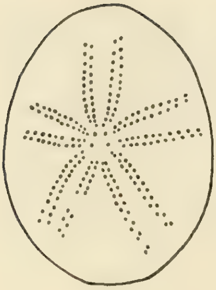
Fibularia alabamensis Cooke, 1959, U.S. Geol. Surv. Paper 321, p. 31, pl. 9, figs. 20-22.

Fibularia alabamensis Cooke.—Kier, 1966, Smithsonian Misc. Coll., vol. 151, no. 9, p. 6, text-figs. 1, 2, 3, 5B, 6A.

There are three specimens in the collection which can be referred with little doubt to this species. I can find no significant difference between these specimens and the holotype of this species.

Types.—Holotype USNM 372887; figured specimen USNM 650744.

Intervals in test well.—1135 feet.



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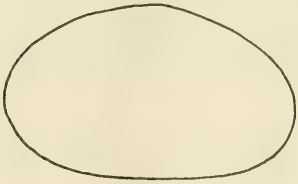

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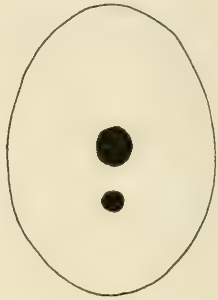

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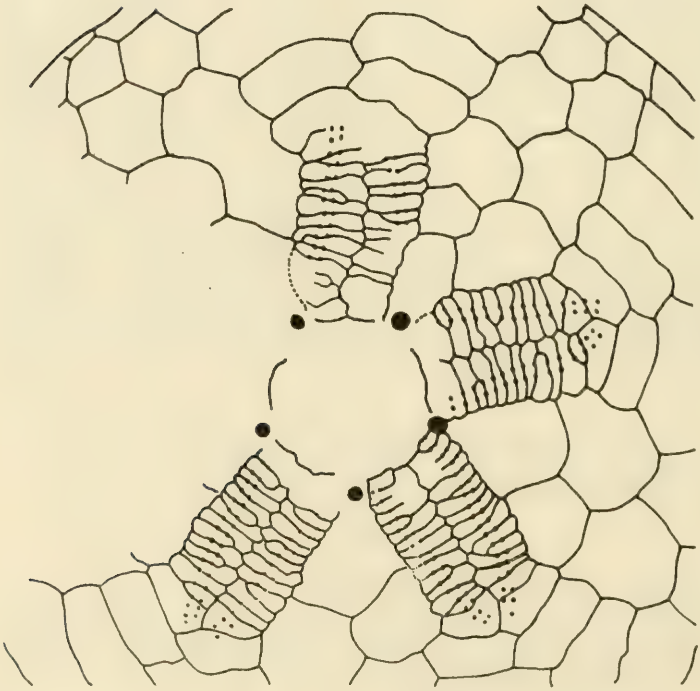

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FIGURES 24–27.—24–26, *Fibularia alabamensis* Cooke. 24, 25, 26, Adapical, left side, adoral views of USNM 650744 from the test well level 1135 feet; × 5. 27, *Durhamella* cf. *D. floridana* (Twitchell). Plate arrangement of USNM 650741 from the test well level 1135-1160 feet showing the pseudocompound plates in the petals and the single plate terminating each interambulacrum; × 7.

Family NEOLAGANIDAE Durham

DURHAMELLA Kier, new genus

Type species.—Laganum ocalanum Cooke.

Description.—Test small to medium in size, low, with flat adoral surface. Plates of adapical surface may or may not be tumid, with sutures depressed. The apical system has five genital pores, and the pores occur within or without the fused genital plates. The hydropore opens in one or two slits. The petals are wide near the apical system and extend approximately one-half the distance from the apical system to the margin. The pores are conjugate, but the outer pore is not in a slit, only elongated transversely. Pseudocompound plates are present in the petals with approximately six to eight in each petal. The accessory pores occur along the transverse sutures of the ambulacral plates adapically, but adorally throughout the basicoronal and first coronal ambulacral plates. The interambulacra terminates at the apical system, with a single quadrangular plate. Adorally, the basicoronal plates have a circular to subpentagonal outline, with a single plate in each interambulacrum, double plates in each ambulacrum. The first coronal ambulacral plates are considerably larger than the basicoronal ambulacral plates. The first coronal interambulacral plates are high, extending beyond the first coronal ambulacral plates. The periproct is inframarginal, and the interior supports are concentric. No food grooves are present.

Comparison with other genera.—Although the type species of this genus has been referred in the past to *Laganum,* Durham (1954, p. 684; 1955, p. 145) indicated that he did not feel that the New World "laganids" really were laganids. Neither Cook nor Durham were aware that pseudocompound plates were present in *Durhamella ocalana.* The presence of these plates, together with the fact that the basicoronal plates are not arranged in a pentagonal star, and the first pair of postbasicoronal plates is considerably larger than the remaining plates, indicate that *Durhamella* should be placed in the Neolaganidae and not Laganidae.

Durhamella differs from all the other genera of the Neolaganidae in having five instead of four genital pores. It appears to be the most primitive genus in the family, as indicated by its five genital pores, fewer pseudocompound plates, and by the outer pore not being in a pronounced slit. Of all the genera in the family, it most resembles *Weisbordella.* The adoral plate arrangement in two genera is almost identical, but the petals in *Weisbordella* have many more pseudocompound plates.

The genus is known only from the middle and late Eocene of southeastern United States and includes one other species, *Durhamella floridana* (Twitchell).

It is appropriate at this time to redescribe the type species, *Durhamella ocalana* (Cooke). A large number of specimens are now available which make it possible to define in greater detail the species.

DURHAMELLA OCALANA (Cooke)

Plate 6, figures 1-5; Plate 7, figures 1-3; Plate 8, figures 2, 3; Figures 28-30, 32-34

Laganum ocalanum Cooke, 1942, Journ. Paleont., vol. 16, no. 1, p. 23, pl. 2, figs. 7-10.

Laganum ocalanum Cooke.—Fischer, 1951, Florida Geol. Surv. Geol. Bull. 32, pt. 2, p. 57.

Laganum ocalanum Cooke.—Durham, 1954, Journ. Paleont., vol. 28, no. 5, p. 684.

Laganum ocalanum Cooke.—Durham, 1955, Univ. California Publ., Geol. Sci., vol. 31, no. 4, p. 1945.

Laganum ocalanum Cooke.—Cooke, 1959, Geol. Surv. Prof. Paper 321, p. 51, pl. 20, figs. 11-15.

Material.—This description is based on the holotype and over 100 specimens from the Ocala Limestone at the St. Catherine Rock Company quarry, west of St. Catherine, south of the railroad track, Sumter County, Florida.

Shape and size.—The specimens vary in length from 9.4 mm to 35.3 mm in length. The marginal outline is subpentagonal, with the anterior pointed, the posterior blunted, and with the greatest width anterior to the center. The width averages 90 percent of the length in the smaller specimens, 92 percent in the larger, and there is little variation in the length-width ratio, as is evident from the scattergram (Figure 28). The test is low, with the height approximately 20 percent of the length in the smaller specimens, 10-20 mm long, but only 14 percent in the larger (Figure 29). The greatest height is at the apical system. The margin is thick, and the adapical surface is slightly depressed between the margin and the midlength of the petals. The sutures are depressed along the sutures of the adapical interambulacral plates between the petals and along the ambulacral plates beyond the petals in most of the specimens. In only a few specimens are the sutures not depressed. The adoral surface is flat.

Apical system.—The system is slightly anterior or central and has five genital pores. Genital pores are evidently first introduced in specimens approximately 9 to 10 mm long. The smallest specimen,

9.4 mm long, has very small pores, but they are absent in a specimen 9.8 mm long, but present in one 10.7 mm long and 11.4 mm long. A specimen 11.9 mm long has no pores, but all the specimens larger have pores. The position of the pores in the apical system is variable. In 13 specimens the pores perforate the fused genital, but in 5 speci-

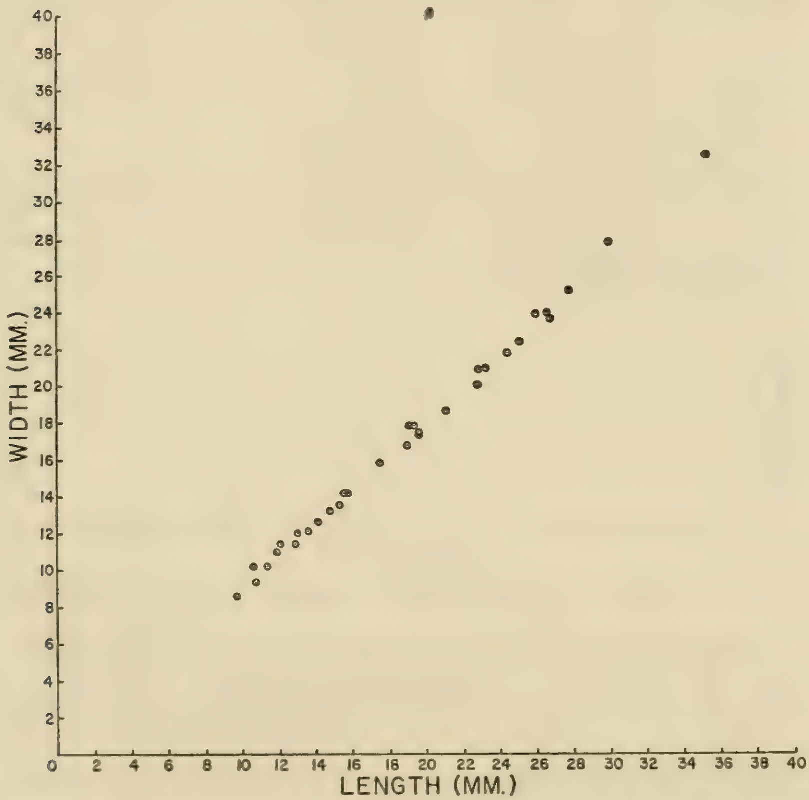


FIGURE 28.—*Durhamella ocalana* (Cooke). Scattergram of the length and width showing the slight variation in this ratio.

mens they occur on the edge of the fused genitals. The size of the pores is also variable, but no dimorphism is evident. The hydropore opens onto the surface of the fused genitals in one or two small slits. The apical system is larger relative to the size of the test in the smaller specimens than in the larger; the system is 20 percent as long as the test in a specimen 9.4 mm long (pl. 6, fig. 3), but only 14 percent in a specimen 35.3 mm long.

Ambulacra.—The petals are wide near the apical system and taper

distally. Petal III extends one-half the distance from the apical system to the margin, the other petals less than one-half. The pores are conjugate, with the outer pore slightly elongate but not in a pronounced slit, and situated distal to the inner pore of the same pair. Petals II, III, and IV have approximately the same number of pore-pairs, but petals V and I have an average of two more pore-pairs in a single poriferous zone than in the other petals. A specimen 9.8 mm long has 12 pore-pairs in a single poriferous zone in petal III, a specimen 14.8 mm has 20, and a specimen 35.3 mm has 36 (Figure 30).

Pseudocompound plates are present in the petals, with six to eight in each petal in the larger specimens (Figure 31).

The plates at the extremities of the petals are pierced by two or three pore-pairs in each plate. Both pores of a pair are not in the same plate on some of these plates: one pore is in one plate, its partner on an adjacent plate.

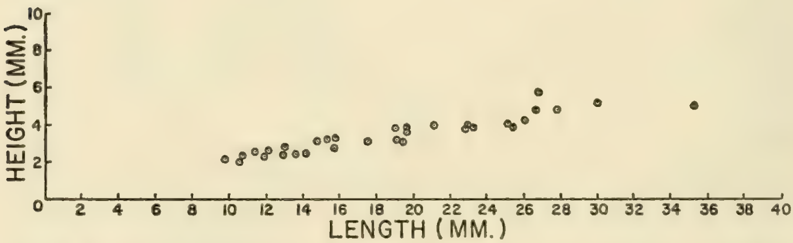


FIGURE 29.—*Durhamella ocalana* (Cooke). Scattergram of the length and height.

The accessory pores are confined to the ambulacra. Adapically, the pores are common beyond the petals where they are concentrated along the transverse sutures in several lines of pores. A few are also in adradial sutures, but none in the perradial. Adorally the pores are more numerous. They are most concentrated along the adradial suture, where they form a conspicuous line (pl. 7, fig. 3), but are not concentrated in the transverse. They occur throughout the basicoronal and first coronal ambulacral plates. Buccal pores are present in the basicoronal and ambulacral plates at the edge of the peristome.

Adapical interambulacra.—The interambulacra terminate at the apical system with a single, large quadrangular plate.

Adoral plate arrangement.—The basicoronal plates have a circular outline, with a single plate in each interambulacrum, double plates in each ambulacrum. The interambulacra are approximately of the same width as the ambulacra except for interambulacrum 5, which is slightly narrower. The first coronal ambulacral plates (Figure 33)

are considerably larger than the basicoronal ambulacral plates and the younger coronal ambulacral plates. The first coronal interambulacral plates are high, extending beyond the first coronal ambulacral plates and are much larger than the basicoronal and younger coronal interambulacral plates.

Peristome.—The peristome is slightly anterior of the center and

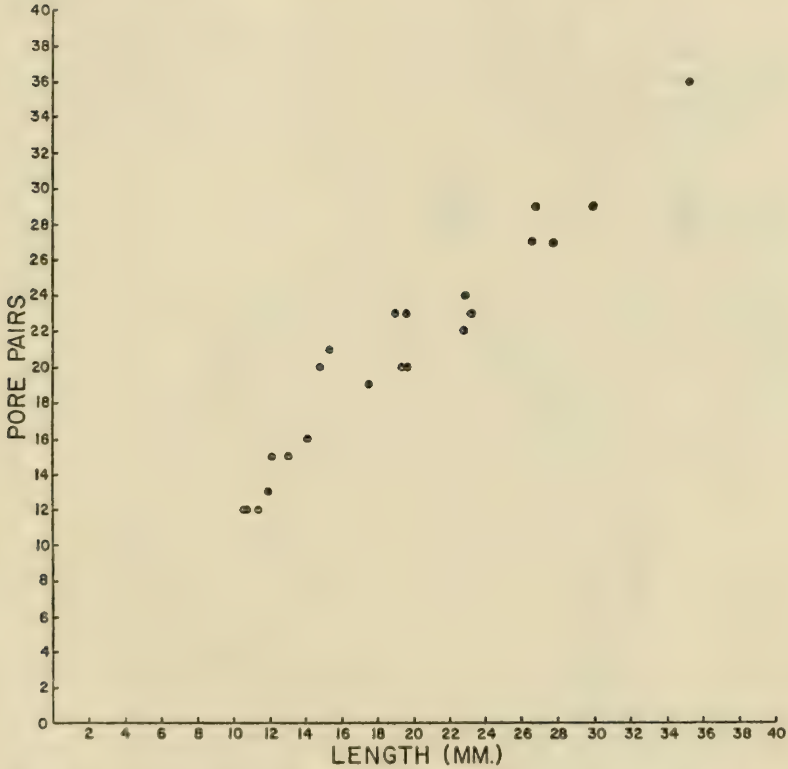
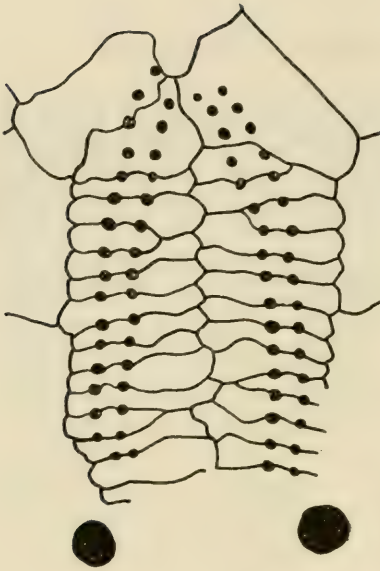


FIGURE 30.—*Durhamella ocalana* (Cooke). Scattergram of the number of pore-pairs in a single poriferous zone of petal III.

pentagonal, with the anterior margin blunted, the posterior pointed. The opening is small, only 1.6 mm high in a specimen 27.7 mm long (height of peristome 6 percent of length of test), but in the smaller specimens the peristome is larger relative to the length of the test (12 percent in a specimen 9.4 mm long). A slight ridge or flange is present behind each pair of buccal pores.

Periproct.—The opening is circular, to slightly elongated trans-



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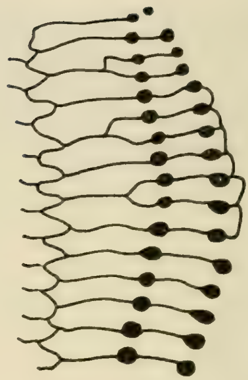

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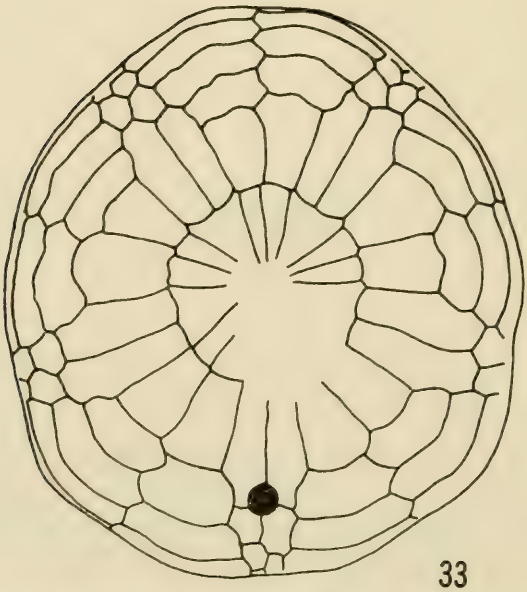

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FIGURES 31-33.—31, *Durhamella* cf. *D. floridana* (Twitchell). Plate arrangement in petal III of USNM 650741 from the test well level 1135-1160 feet. Note the pseudocompound plates and presence of several pore-pairs in the distal plates of the petal. Some of the pore-pairs in these distal plates are partly on one plate and partly on an adjacent one; $\times$ 20. 32-33, *Durhamella ocalana* (Cooke). 32, Plate arrangement of part of petal I of USNM 650742 showing the pseudocompound plates; late Eocene Ocala Limestone, St. Catherine Rock Company quarry, west of St. Catherine, south of railroad track, Sumter County, Florida; $\times$ 20. 33, Adoral view showing plate arrangement of USNM 650743 from same locality as specimen in Figure 32; $\times$ 4.

versely, and is small, only 1.23 mm high in a specimen 35.3 mm long. It is inframarginal, occurring between the first and second pair of coronal plates, and situated near the posterior margin at a distance from that margin equal to 9 percent of the length of the test.

Interior supports.—Concentric supports are strongly developed, with approximately three extending deep into the ambulacrum for each radial support.

Lantern and supports.—The lantern supports are interradial in position and interambulacral in origin.

Types.—Holotype USNM 372873; figured paratypes USNM 498993; figured specimens USNM 562288, 650727, 650728, 650729, 650730, 650731, 650732, 650733.

Comparison with other species.—Durhamella ocalana is quite similar to *Durhamella floridana,* both species having similar petals, length-width, length to height ratios, similar peristomes, and similar adoral plate arrangement. The difference in the species is that in *Durhamella ocalana* the adapical interambulacral plates and the ambulacral plates beyond the petals are depressed around their sutures, producing tumid plates, whereas in the holotype of *Durhamella floridana* this tumidity is absent. In *Durhamella ocalana* the test is wider anteriorly and the margin more angular. Finally, the periproct is more posterior in *Durhamella ocalana,* as is evident in a scattergram (Figure 34).

DURHAMELLA cf. D. FLORIDANA (Twitchell)

Plate 8, figure 1; Plate 9, figures 1-5; Plate 10, figures 1-3; Figures 27, 31, 34-43

Material.—Thirty specimens.

Shape and size.—The specimens vary in length from 3.1 mm to 20 mm. The marginal outline is circular, to subpentagonal, with the anterior slightly pointed and the posterior blunted in some specimens. The test is wide, with little variation in the length-width ratio (Figure 35). The width averages 90 percent of the length in the smaller specimens (between 4 mm and 6 mm long) and 93 percent in the larger (over 13 mm long). The greatest width is central or slightly posterior of the center. The test is low, with the height approximately 29 percent of the length in smaller specimens (6 mm long), 23 percent in specimens 10 mm long, and 17 percent in specimens over 17 mm long (Figure 36). The greatest height is at the apical system. The margin is thick, and the adapical surface is slightly depressed between the edge of the apical system to beyond the ends of the petals. The sutures are depressed along the adapical interambulacral plates between the petals

and the ambulacral plates beyond the petals in a few of the specimens. The adoral surface is flat to very slightly depressed.

Apical system.—The system is slightly anterior of center and has

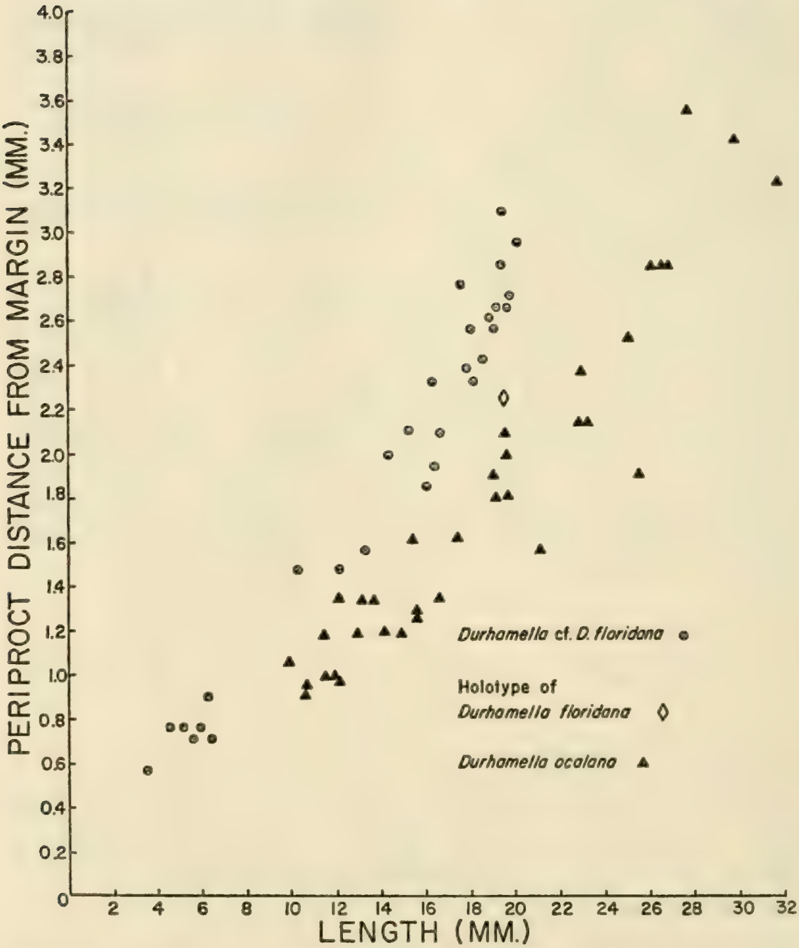

FIGURE 34.—A scattergram showing the position of the periproct in *Durhamella floridana* (Twitchell), *Durhamella* cf. *D. floridana*, and *D. ocalana* (Cooke).

five genital pores. The smaller specimens, from 3.1 to 6.2 mm long, have no genital pores (Figure 37), but they are present in the next larger specimen, 10.2 mm long, and in all the rest in which the apical system is preserved. The pores are at the edge of the apical system (Figure 38) in the suture between the system and the last inter-

ambulacral plate in all the specimens except the two smallest having pores (10.2 and 12.1 mm long). In these two specimens the pores penetrate the fused genital plates. Probably the pores are first introduced within the fused genital and then shift out to the edge during the growth of the echinoid, but more specimens would be needed to be certain of this conjecture. The hydropore opens onto the surface

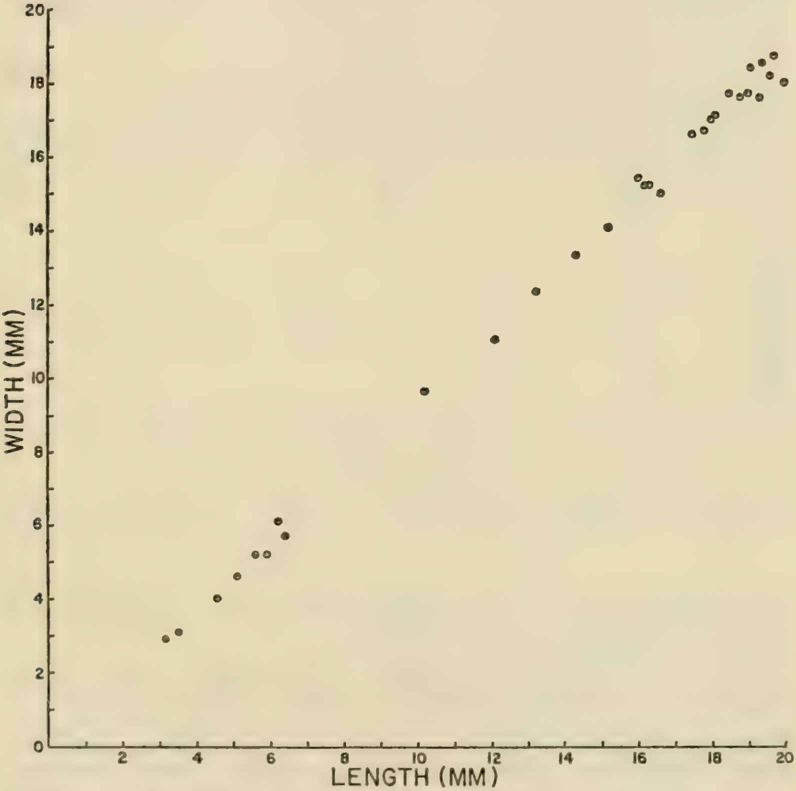

FIGURE 35.—*Durhamella* cf. *D. floridana* (Twitchell). A scattergram showing the ratio of length to width.

of the fused genitals in one or two small slits. The apical system is larger relative to the size of the test in the smaller specimens than in the larger; the system is 26 percent long in a specimen 19.7 mm long.

Ambulacra.—The petals are wide near the apical system and taper distally. Petal III extends one-half the distance from the apical system to the margin; the other petals less than one-half. The pores are conjugate, with the outer pore slightly elongate but not in a

pronounced slit, and situated distal to the inner pore of the same pair. Petal III has approximately the same number of pore-pairs as petals II or IV. Petals V and I have up to four more pore-pairs in a single poriferous zone than the other petals. A specimen 3.5 mm long (Figure 43) has three pore-pairs in petals II, III, and IV, but four in petals V and I. A specimen 6.2 mm long has six pore-pairs in petals II, III, and IV, but seven in petals V and I. A specimen 17.5 mm long has 16 pore-pairs in a single zone in petals II, III, and IV, and 18 in petals V and I.

Pseudocompound plates are present in the petals. Six to eight occur in each petal in the larger specimens (Figure 31).

The plates at the extremities of the petals are pierced by two or three pore-pairs in each plate. Both pores of a pair are not in the

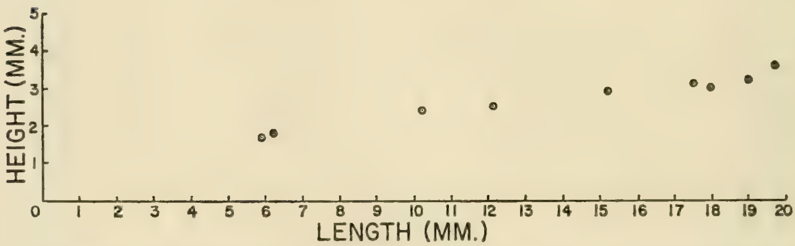

FIGURE 36.—*Durhamella* cf. *D. floridana* (Twitchell). A scattergram showing the ratio of length to height.

same plate on some of these plates: one pore is on one plate, its partner on an adjacent plate (Figure 31).

The accessory pores are confined to the ambulacra. Adapically, the pores are common beyond the petals where they are concentrated along the transverse sutures in several lines of pores. A few are also in adradial sutures, but none in the perradial. Adorally, the pores are more numerous. They are most concentrated along the adradial suture, where they form a conspicuous line (pl. 8, fig. 1), but are not concentrated in the transverse. They occur throughout the basicoronal and first coronal ambulacral plates. Buccal pores are present in the basicoronal ambulacral plates at the edge of the peristome.

Adapical interambulacra.—The interambulacra terminate at the apical system (Figure 41), with a single, large quadrangular plate. On a small specimen, only 4.9 mm long, this single plate is much slimmer relative to other plates in the series than in the larger specimens.

Adoral plate arrangement.—The basicoronal plates have a circular outline, with a single plate in each interambulacrum, double plates in each ambulacrum. The interambulacra are approximately of the same width as the ambulacra except for interambulacrum 5, which is slightly narrower. The first coronal ambulacral plates (Figure 40) are considerably larger than the basicoronal ambulacral plates and the younger coronal ambulacral plates. The first coronal interambulacral

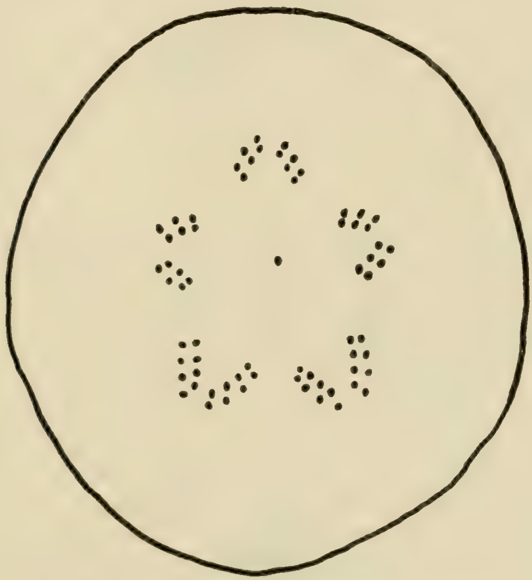

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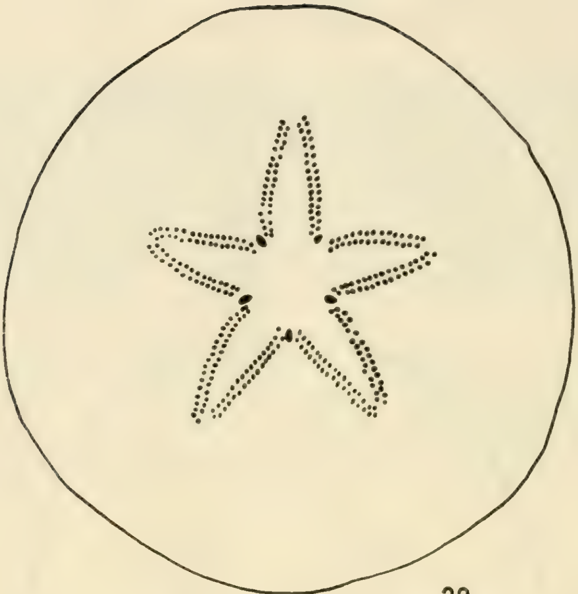
FIGURE 37.—*Durhamella* cf. *D. floridana* (Twitchell). Adapical view of a small specimen showing the lack of genital pores and the few petaloid pore-pairs; test well level 1135-1145 feet; × 24.

plates are high, extending beyond the first coronal ambulacral plates, and are much larger than the basicoronal and younger coronal interambulacral plates. The adoral plates are visible on a specimen only 5.9 mm long. The difference in the plate arrangement (Figure 39) from the large specimens is that the first coronal ambulacral plates are much lower, no higher than the basicoronal plates, and the first interambulacral plates are wider than in an adult.

Peristome.—The peristome is slightly anterior of the center and pentagonal, with the anterior margin blunted, the posterior pointed.



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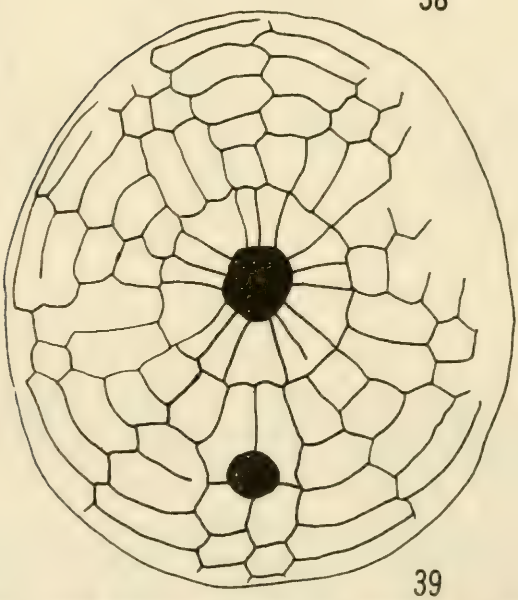

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FIGURES 38-39.—*Durhamella* cf. *D. floridana* (Twitchell). 38, Adapical view showing the petaloid pores in USNM 650738 from the test well level 1135-1160 feet. A photograph of this specimen is on plate 10, figure 1; × 5. 39, Adoral view of USNM 650751 from the test well level 1135 feet showing the plate arrangement in a small specimen as compared to a large specimen illustrated in Figure 40. Note the smaller first coronal plates in the smaller specimen; × 15.

The opening is small, only 0.95 mm high in a specimen 15.2 mm long (height of peristome 6 percent of length of test), but in smaller specimens (Figure 42) the peristome is larger relative to the length of the test (11 percent in a specimen 4.52 mm long). A slight ridge or flange is present behind each pair of buccal pores.

Periproct.—The opening is circular, to slightly elongated transversely, and small, only 0.71 mm high in a specimen 18.1 mm long. It is inframarginal, occurring between the first and second pair of coronal plates. Its position varies slightly, according to the size of the specimen. On the smaller specimens, under 8 mm long, the distance from the posterior edge of the periproct to the posterior margin is only 6 percent of the length of the test, whereas in the larger specimens it is 14 percent. This allometry is evident in a scattergram (Figure 34).

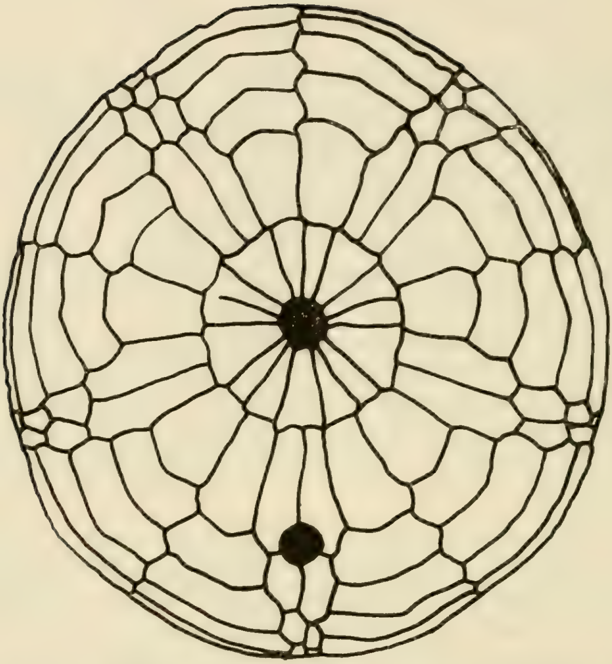
Interior supports.—In a small specimen, 3.14 mm long (pl. 10, fig. 3), the supports are radial, with a pair in each interambulacrum. They extend from the margin approximately midway to the edge of the peristome where they curve at right angles toward the ambulacra. In a large specimen, 18.1 mm long (pl. 10, fig. 2), concentric supports are strongly developed, with approximately three extending from each radial support deep into the ambulacrum.

Lantern and supports.—No lantern is visible on any of the specimens, and not enough specimens are available to permit dissection. The five lantern supports are interradial and have a slight ridge extending down the middle of the front face, with a depression on each side. Enough plate sutures are visible so that it can be seen that these supports are interambulacral in origin.

Types.—Figured specimens USNM 650734, 650735, 650736, 650737, 650738, 650739, 650740, 650751, 650752.

Intervals in test well.—Spoil from ditch; 1130-1135 feet, 1135-1140 feet, 1135-1160 feet.

Remarks.—These specimens have many features in common with *Durhamella floridana* and are tentatively referred to this species. Unfortunately not enough specimens of *D. floridana* have been found to make it possible to know with any certainty its specific characters. The test well specimens and the holotype of *D. floridana* are similar in shape, petal length, and number of pore-pairs in each petal. The periproct, however, is slightly more posterior in *D. floridana* than in the test well specimens, as is evident in a scattergram (Figure 34). In *D. floridana* the petals are more constricted at the apical system, but the shape of the petals is quite variable in a large population



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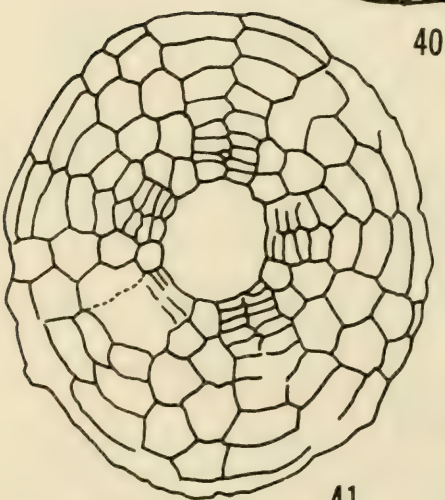

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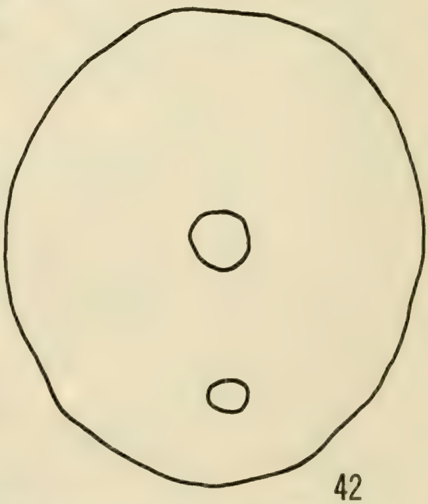

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FIGURES 40-42.—*Durhamella* cf. *D. floridana* (Twitchell). 40, Adoral view of USNM 650735 from the test well level 1135-1160 feet showing the plate arrangement in a large specimen as contrasted to that in the small specimen figured on Figure 39; × 6.5. 41, Adapical view of USNM 650752 from the test well level 1130-1135 feet showing the plate arrangement in a small specimen. Note that the single terminating place in each interambulacrum is smaller relative to the other plates than in a larger specimen; × 15. 42, Adoral view of the same specimen showing the proportionally larger peristome in a smaller specimen than that found in a larger, such as in Figure 40.

of *D. ocalana,* which was studied, and may have been variable also in this species. Until more specimens of both *D. floridana* and of the test well population have been found, it seems inadvisable to attempt to decide whether or not the test well specimens are conspecific.

The test well specimens seem quite distinct from *D. ocalana.* In *D. ocalana,* the adapical interambulacral plates and a few of the ambulacral plates beyond the petals are depressed around their sutures, producing tumid plates. In the test well specimens, this tumidity is

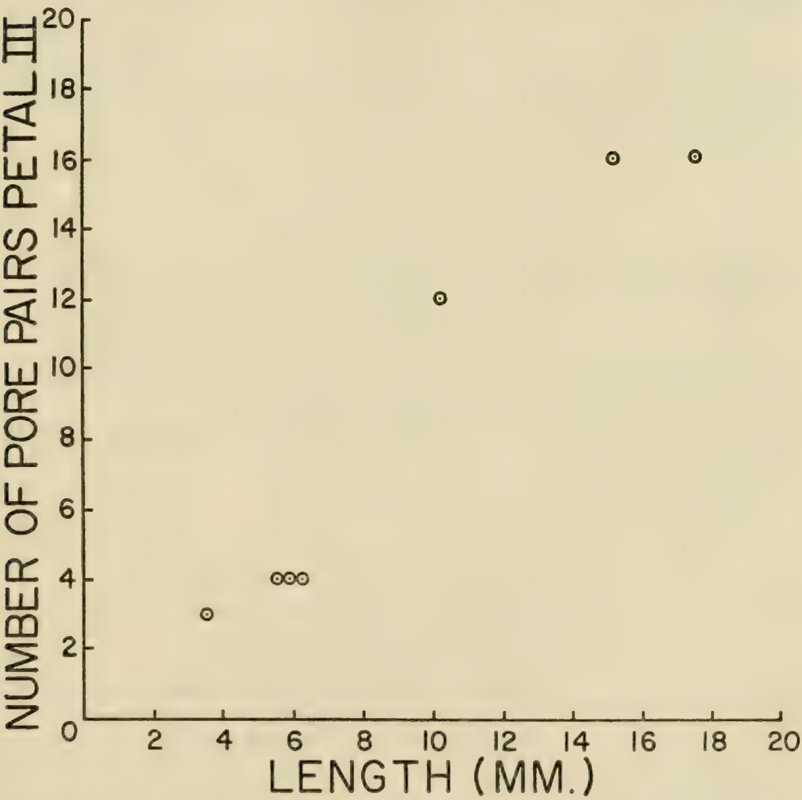

FIGURE 43.—*Durhamella* cf. *D. floridana* (Twitchell). A scattergram showing the number of pore-pairs in a single poriferous zone relative to the length of the test.

less pronounced and is absent entirely in many specimens. In *D. ocalana,* the apical and petaloid areas are more inflated, the marginal outline more angular, and the test is wider more anteriorly. Finally, the periproct is more posterior in *D. ocalana* than in the test well

specimens, as is evident in a scattergram (Figure 34). Although different, *D. ocalana, d. floridana,* and the test well specimens are quite similar and are obviously closely related.

Family Uncertain

Genus PENTEDIUM Kier

When this genus was erected (Kier, 1967, p. 989), I had hoped that by the time I had finished the study of these test well echinoids, the family relationship of this genus would be apparent. The family relationship, however, is no clearer now, and I still hesitate to erect a new family on only one species. A correction should have been made in my 1967 paper. In the third line of the abstract, the words "of the family Neolaganidae" should have been deleted.

PENTEDIUM CURATOR Kier

Plate 4, figures 3, 4; Plate 5, figure 6

Pentedium curator Kier, 1967, Journ. Paleont., vol. 41, no. 4, p. 990, pl. 129, figs. 3, 4; pl. 130, figs. 2-7, text-figs. 1-3.

This species, which was described earlier, has been found only in the test well material. It is unusual because it exhibits sexual dimorphism, with the females having brood pouches.

Types.—Holotype USNM 650915; figured paratypes USNM 650916-650923.

Intervals in test well.—1130-1160 feet.

Suborder SCUTELLINA Haeckel

Family PROTOSCUTELLIDAE Durham

Genus PERIARCHUS Conrad

PERIARCHUS species

Plate 5, figures 1-3; Figure 44

Material.—One specimen.

Shape and size.—The specimen is 22 mm long, 20.2 mm wide, and 3.8 mm high. The anterior margin is curved, the posterior blunted—although this may be due to fracturing. The test is low, with its width and the greatest height posterior to the apical system. The adoral surface is flat to slightly concave, the margin is sharp.

Apical system.—The five genital pores occur at the edge of the fused genital plates. Madreporic pores occur throughout the fused genital plates.

Ambulacra.—The petals are of approximately the same length and have their greatest width at their midlength or slightly distal. The outer pore of a pair is elongated transversely. Approximately 27–28 pore-pairs occur in each poriferous zone in each petal. The petals extend slightly more than one-half the distance from the apical system to the margin.

The location of the accessory pores is not clear on the adapical

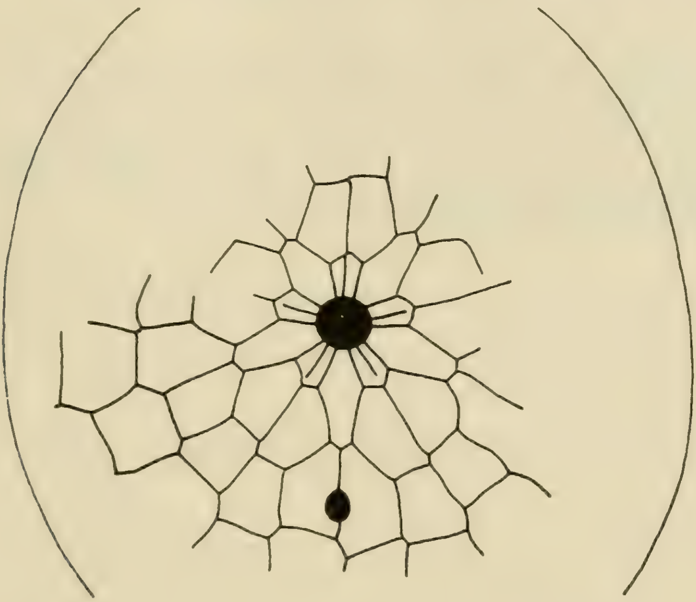

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FIGURE 44.—*Periarchus* species. Adoral view showing the plate sutures where visible. USNM 650724 from test well level 1135-1160 feet; $\times$ 5. A photograph of this specimen is on plate 5, figures 1-3.

surface of the specimen, but adorally they appear to occur through most of the surface of the ambulacral plates.

Adapical interambulacra.—The interambulacra terminate at the apical system in two alternate columns in each area.

Adoral plate arrangement.—The basicoronal ambulacral plates (Figure 44) are paired and small, less than one-half the height of the adjacent interambulacral plates. The basicoronal interambulacral plates are high and extend deeply out into the test, giving a starlike

appearance to the basicoronal plates. The first coronal plates are slightly larger than the others.

Peristome.—The opening is circular and small, 1.28 mm in diameter. The sides of the opening are vertical.

Periproct.—The periproct is inframarginal, located approximately midway between the peristome and the posterior margin. The opening is slightly higher than wide, and is small, only 0.85 mm high. It occurs between the first pair of coronal plates (Figure 44).

Type.—Figured specimen USNM 650724.

Interval in test well.—1135-1160 feet.

Remarks.—This specimen is quite similar to small specimens of *Periarchus lyelli* (Conrad) (pl. 5, figs. 4, 5). More specimens are needed before it can be decided whether it is conspecific or a new species. It appears to differ in having slightly narrower petals and a less pointed anterior margin.

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EXPLANATION OF PLATES

Plate 1

***Lenita patellaris* (Leske)**

1, 2, Adapical and adoral views of specimen from the middle Eocene, Parney, France. Michelin collection, Laboratoire de Paléontologie, Institut de Géologie, Université de Paris, Orsay; $\times$ 12.

***Leniechinus herricki* Kier, new species**

3, 4, Adapical and adoral views of the holotype, USNM 650717, from test well level 1135 feet; $\times$ 10. A view of the peristome is on plate 2, figure 2.

Plate 2

***Leniechinus herricki* Kier, new species**

1, Adapical view of USNM 650718 from test well level 1135 feet; $\times$ 10.

2, Peristome of holotype, USNM 650717, showing the well-developed ridge around the opening; $\times$ 15.

3, Adapical view of larger specimen showing the relatively smaller size of the petaloid pores as compared to those found in a smaller specimen, such as that in figure 1. USNM 650719 from the test well level 1135 feet; $\times$ 6.

4, Left side of same specimen as in figure 3; $\times$ 6.

5, View of interior showing radial supports in the same specimen as in figures 3 and 4. Note the accessory pores in the ambulacra; $\times$ 5.

Plate 3

***Echinocyamus bisexus* Kier, new species**

1, 2, 3, Adapical, left side; adoral views of USNM 650720 from test well level 1130-1135 feet. The large size of the genital pores and their great separation from each other indicates that this specimen was a female; $\times$ 15.

4, Adapical view of a small specimen showing the wide separation of the genital pores and the large size of the madreporite; USNM 650721; $\times$ 20.

5, 6, Adapical and adoral views of holotype, USNM 650722, from the test well level 1135-1145 feet. The small size and closeness of the genital pores to each other indicate that this specimen was a male; $\times$ 15.

Plate 4

***Echinocyamus bisexus* Kier, new species**

1, 2, Adapical and adoral view of USNM 650723 showing the large and widely separated genital pores, indicating that this specimen was probably a female. The accessory pores are visible on the adoral view; from the test well level 1135-1145 feet; $\times$ 15.

***Pentedium curator* Kier**

3, Adapical view of the holotype, USNM 650915, showing the deep pits which are considered to be brooding pouches; test well level 1130-1160 feet; $\times$ 16.

4, Adoral view of paratype, USNM 650916, showing the smaller and closer together genital pores and lack of adapical pits, which suggest that this specimen was a male; test well level 1130-1160 feet; $\times$ 20.

Plate 5

***Periarchus* species**

1, 2, 3, Adapical, adoral, and left side of USNM 650724 from test well level 1135-1160 feet; × 3.

***Periarchus lyelli* (Conrad)**

4, Adoral view showing plate arrangement in USNM 650725 from D. W. Farm, Little Chinquapin Creek, one-half mile NW of Winsatt, Jones County, North Carolina; × 2.

5, Adapical view of USNM 650726 from farm of B. D. Johnson, 2 miles south of Magnolia Depot, Duplin County, North Carolina; × 2.

***Pentedium curator* Kier**

6, Adoral view showing accessory and buccal pores of female paratype, USNM 650919, from the test well level 1135-1160 feet; × 20.

Plate 6

***Durhamella ocalana* (Cooke)**

1, 2, The apical area of two specimens, USNM 650727 and USNM 650728, showing the variation in the position of the genital pores; × 15.

3, Adapical view of small specimen, 9.5 mm long (USNM 650729), showing large size of apical system with genital pores already present; × 5.

4, Adapical view of USNM 650730; × 3.

5, Adoral view showing the basicoronal plate arrangement of USNM 65031; × 4.

All these specimens are from the late Eocene Ocala Limestone at the St. Catherine Rock Company quarry, west of St. Catherine, south of railroad track, Sumter County, Florida.

Plate 7

***Durhamella ocalana* (Cooke)**

1, Adapical view of a large specimen, USNM 650732, from the late Eocene Ocala Limestone at the St. Catherine Rock Company quarry, west of St. Catherine, south of railroad track, Sumter County, Florida; × 3.

2, Left side of holotype, USNM 372873, from the late Eocene Ocala Limestone, 2 miles NE of Sumterville, Florida; × 3.

3. Adoral view of USNM 650733 from same locality as specimen in figure 1; × 3.

***Durhamella floridana* (Twitchell)**

4, 5, 6, Adapical, right side, adoral views of holotype, USNM 137884, from the late Eocene, Ocala Limestone at Johnson's Sink, Levy County, Florida; × 3.

Plate 8

***Durhamella* cf. *D. floridana* (Twitchell)**

1, Adoral view of USNM 650734 showing accessory pores; × 6.

***Durhamella ocalana* (Cooke)**

2, 3, Adapical and adoral views of holotype, USNM 372873, from the late Eocene Ocala Limestone, 2 miles NE of Sumterville, Florida; × 3. A side view of this specimen is on plate 7, figure 2.

Plate 9

Durhamella cf. *D. floridana* (Twitchell)

1, 2, 3, Adapical, adoral, and right side of USNM 650735 from the test well level 1135-1160 feet; ×5, × 5, × 4.

4, View of interior of USNM 650736, showing the lantern supports, from the test well level 1135-1145 feet; × 16.

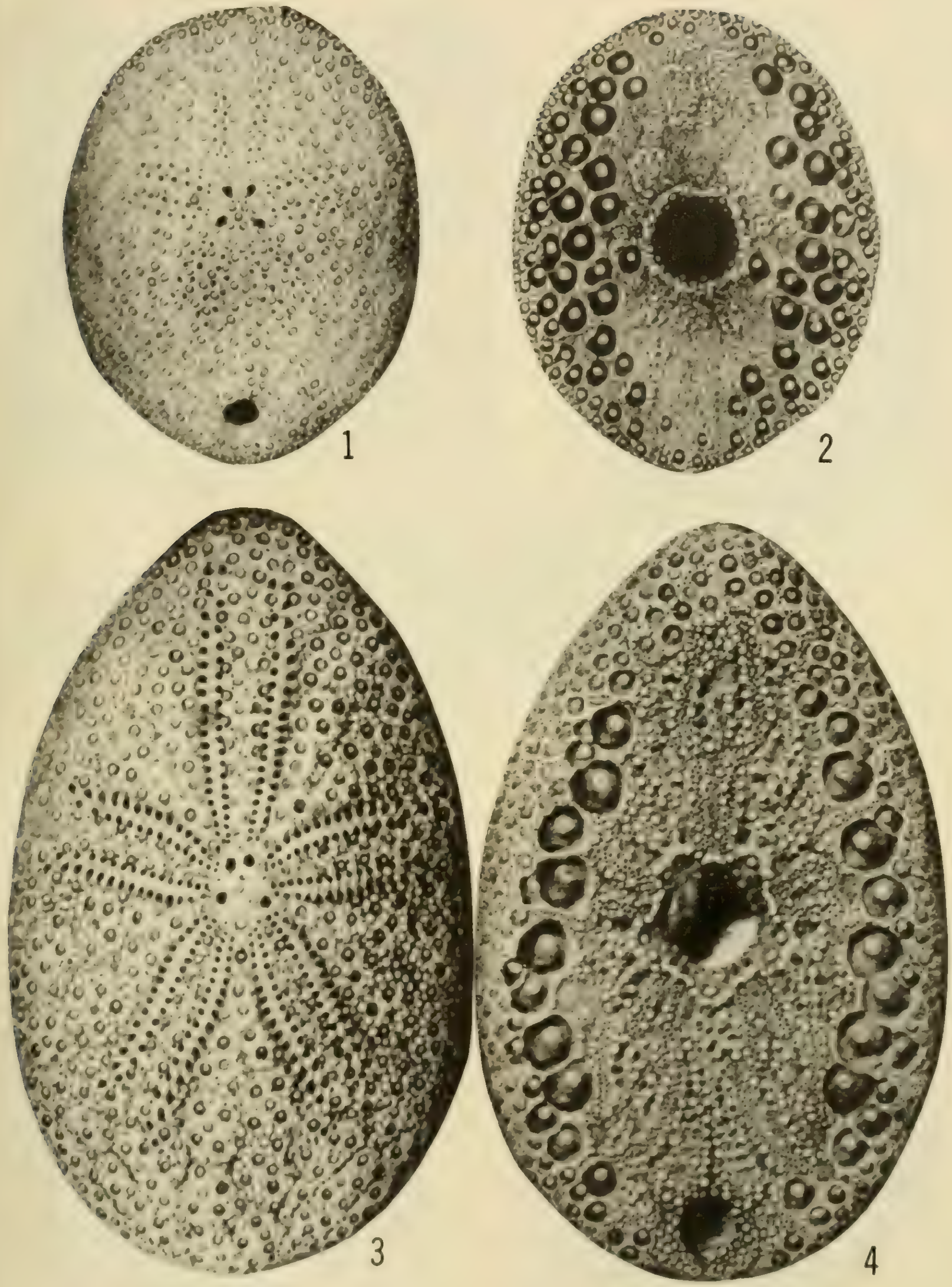
5, Adapical view of USNM 650737 showing the slightly tumid plates found on some of the specimens; from the test well (spoil in ditch); × 3.

Plate 10

Durhamella cf. *D. floridana* (Twitchell)

1, Adapical view of USNM 650738 from the test well level 1135-1160 feet; × 6.

2, 3, Interior view of a large specimen (USNM 650739) and a small specimen (USNM 650740) showing the development of the interior supports; from the test well, USNM 650739 from spoil in ditch, USNM 650740 from level 1135-1160 feet; × 4, × 24.



1, 2, *Lenita patellaris* (Leske); 3, 4, *Leniechinus herricki* Kier, new species

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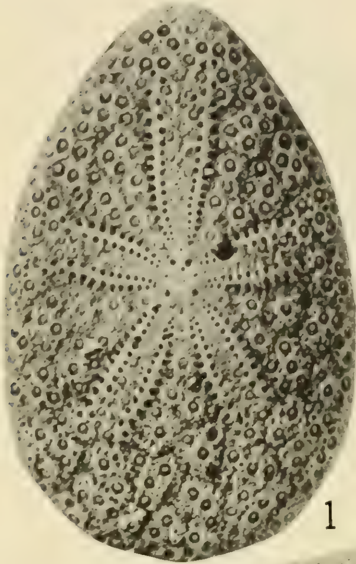

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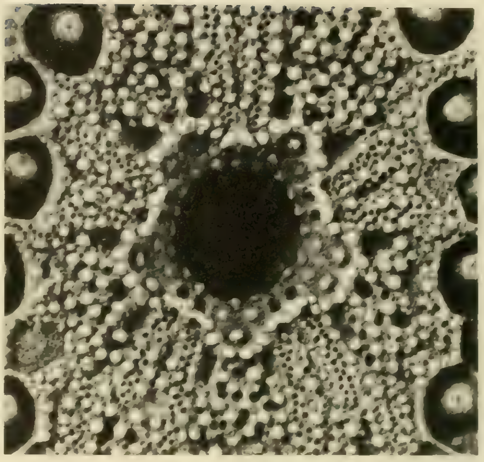

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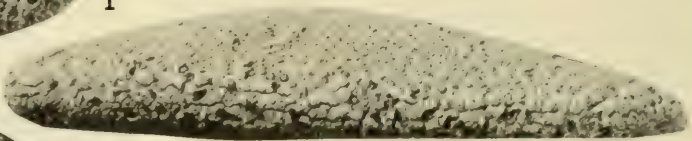

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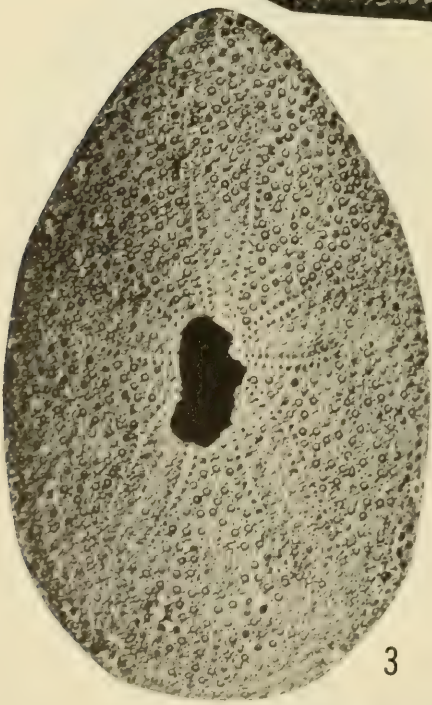

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Leniechinus herricki Kier, new species

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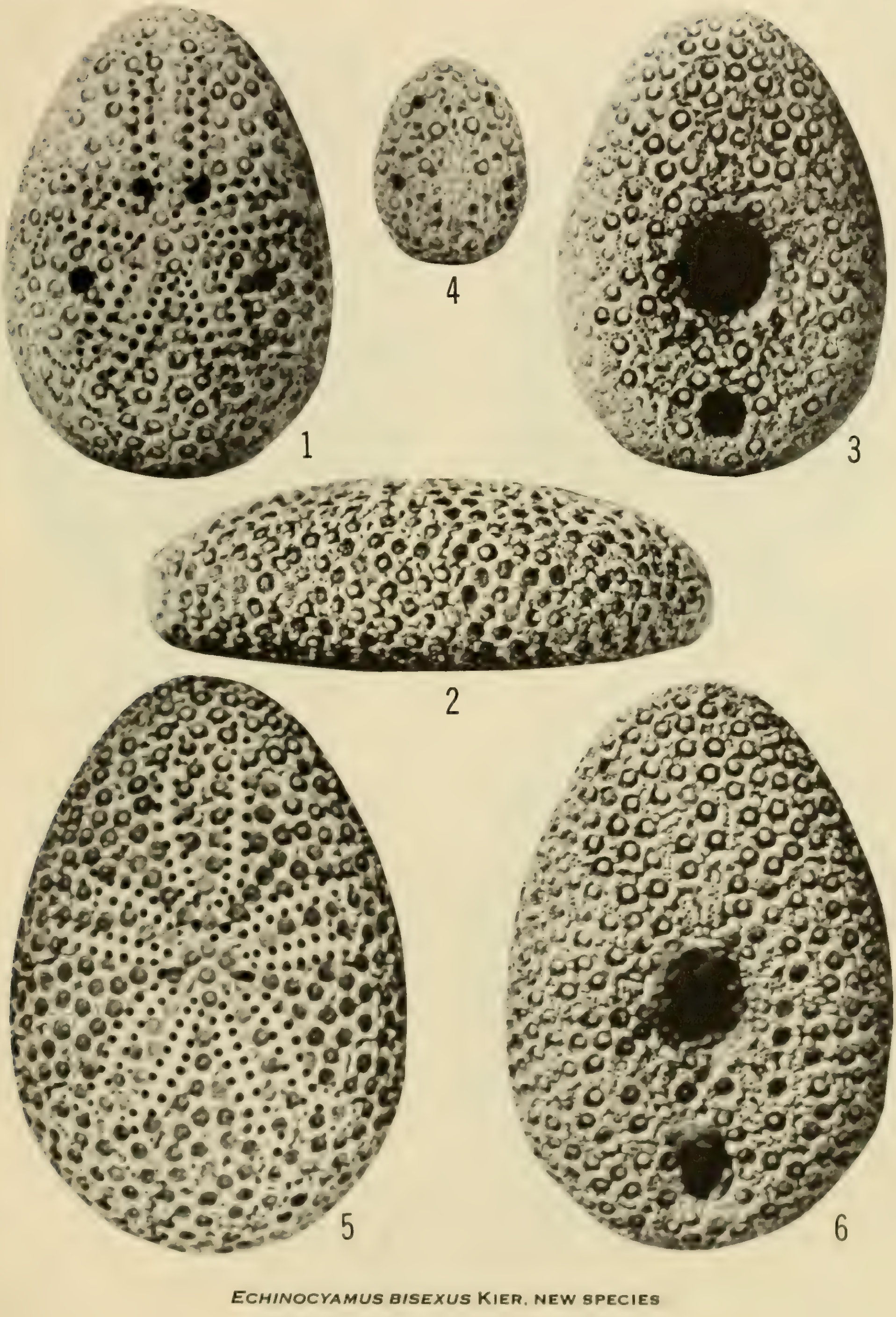

ECHINOCYAMUS BISEXUS KIER, NEW SPECIES

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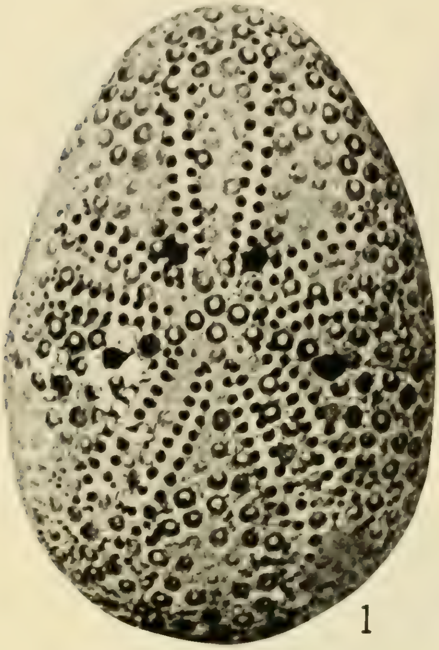
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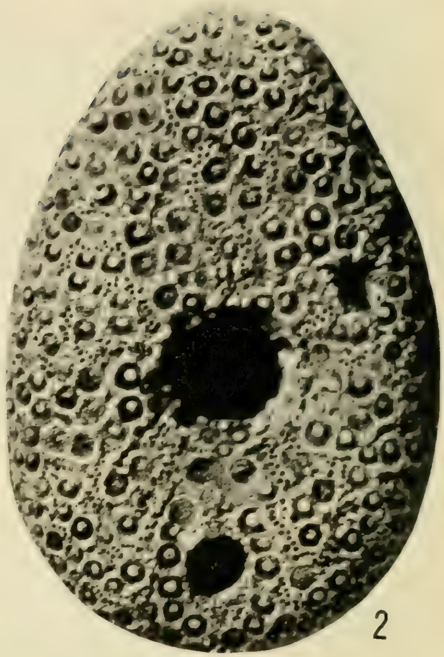
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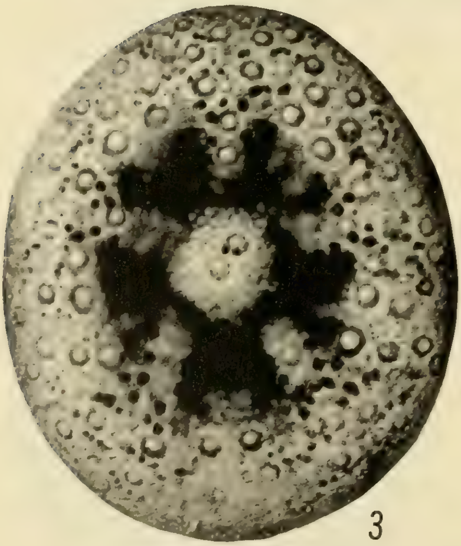
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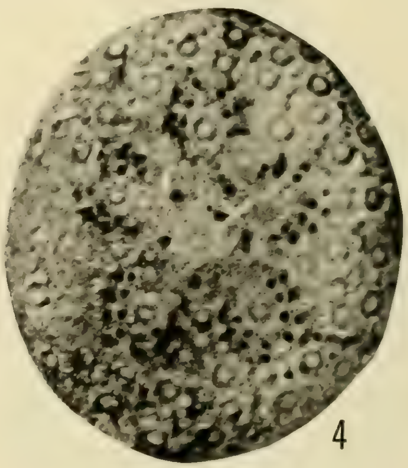
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1, 2, *Echinocyamus bisexus* Kier, new species
3, 4, *Pentedium curator* Kier

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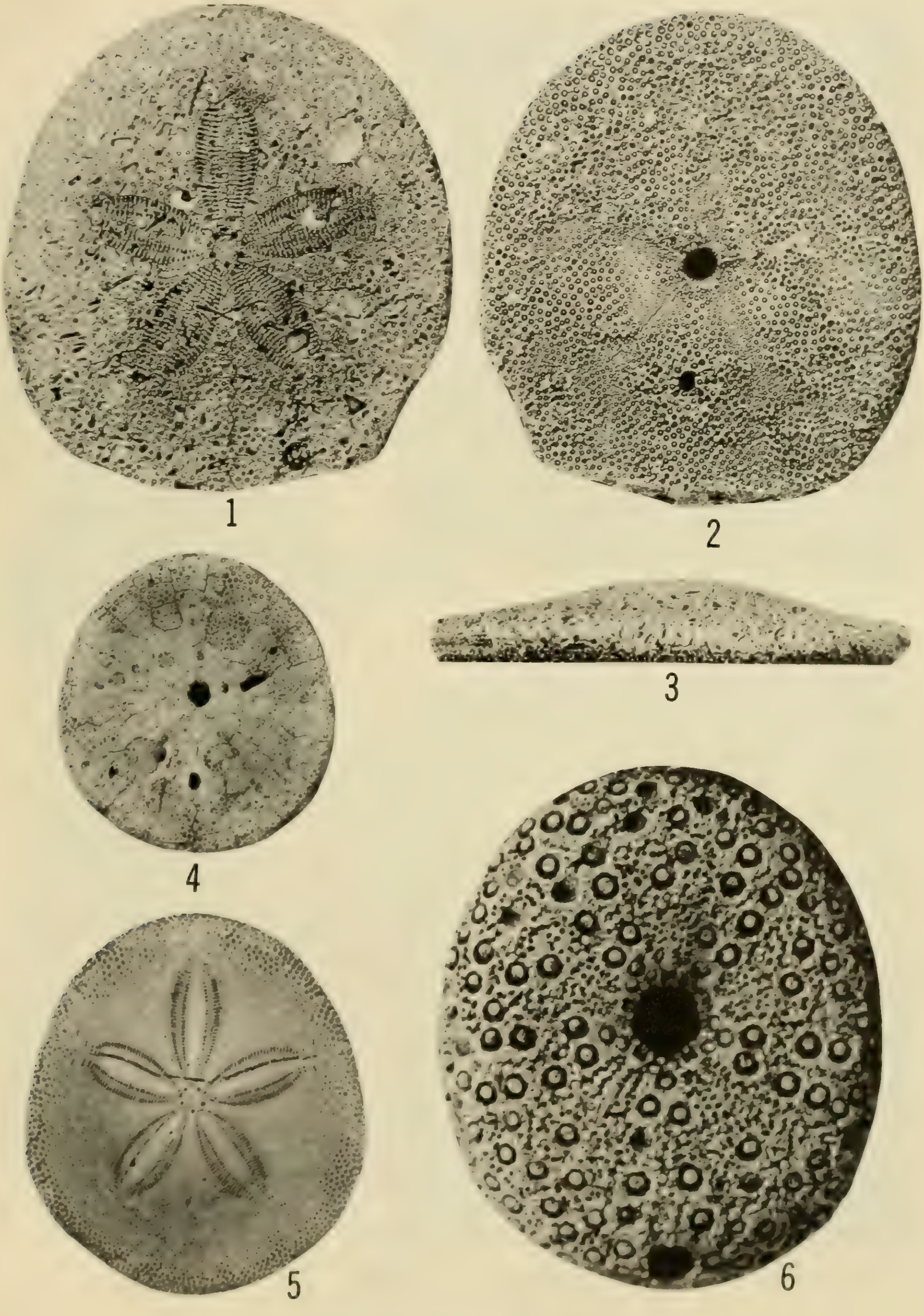

1-3, *Periarchus* species; 4, 5, *Periarchus lyelli* (Conrad); 6, *Pentedium curator* Kier

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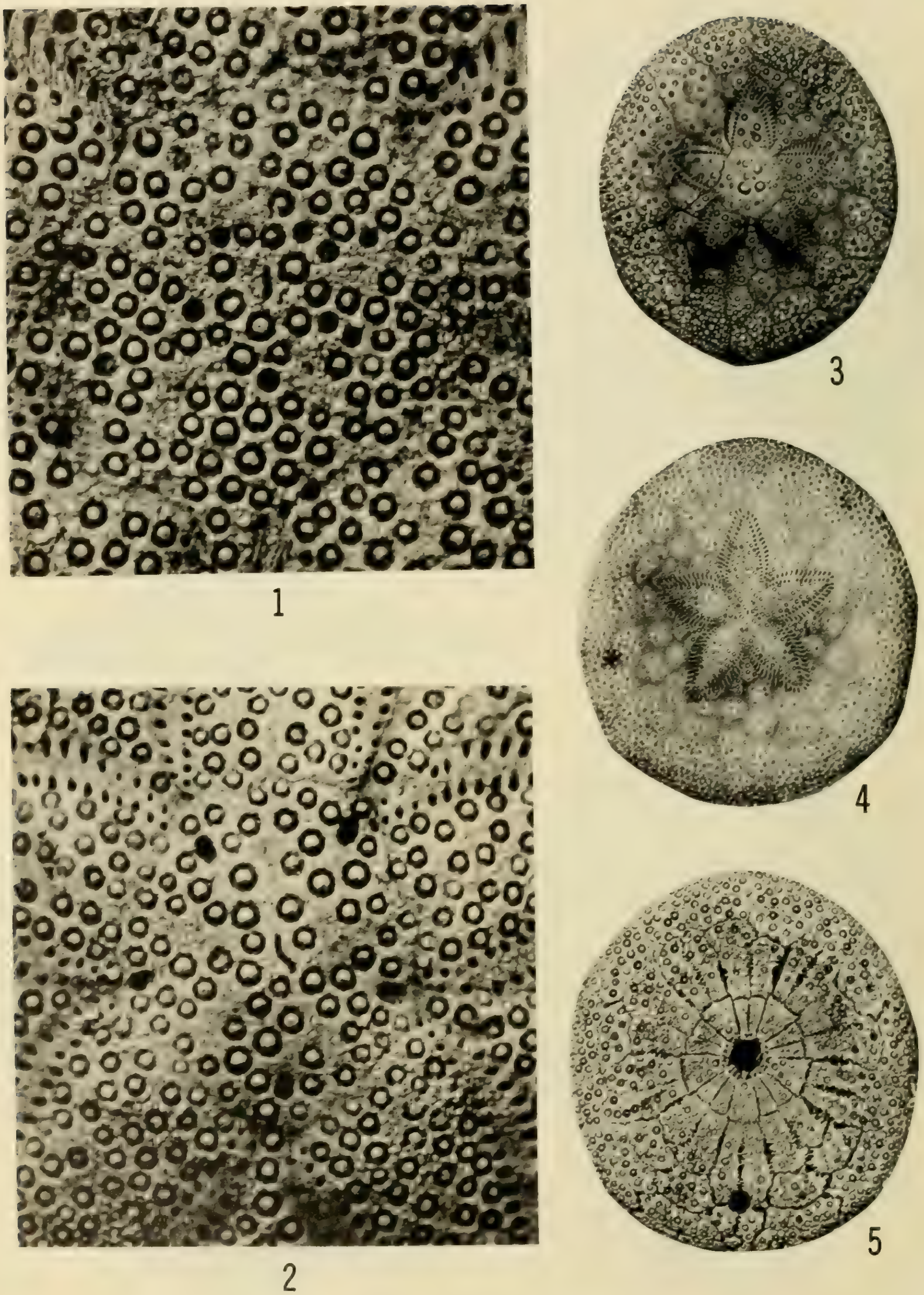

DURHAMELLA OCALANA (COOKE)

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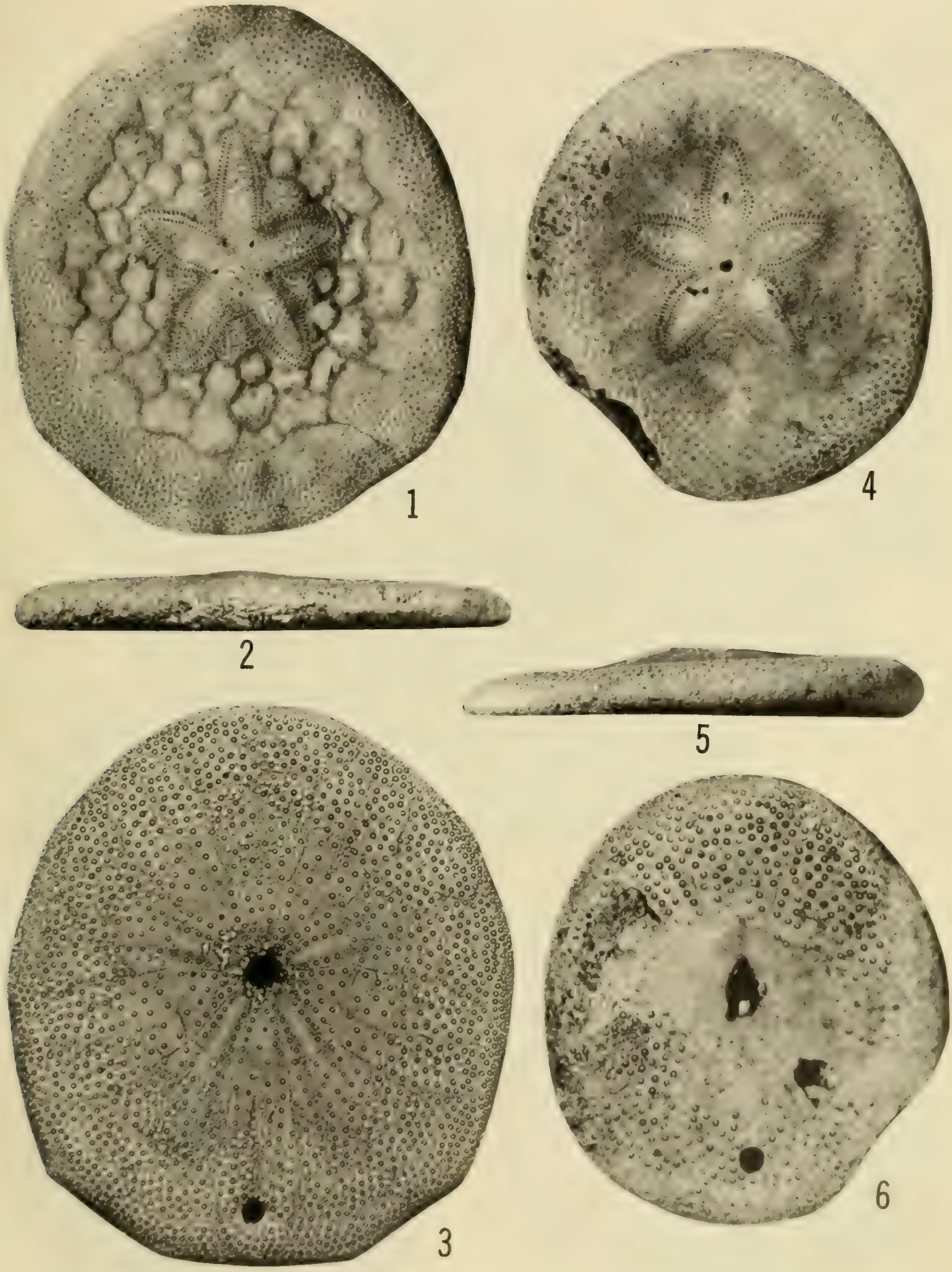

1-3, *DURHAMELLA OCALANA* (COOKE); 4-6, *DURHAMELLA FLORIDANA* (TWITCHELL)

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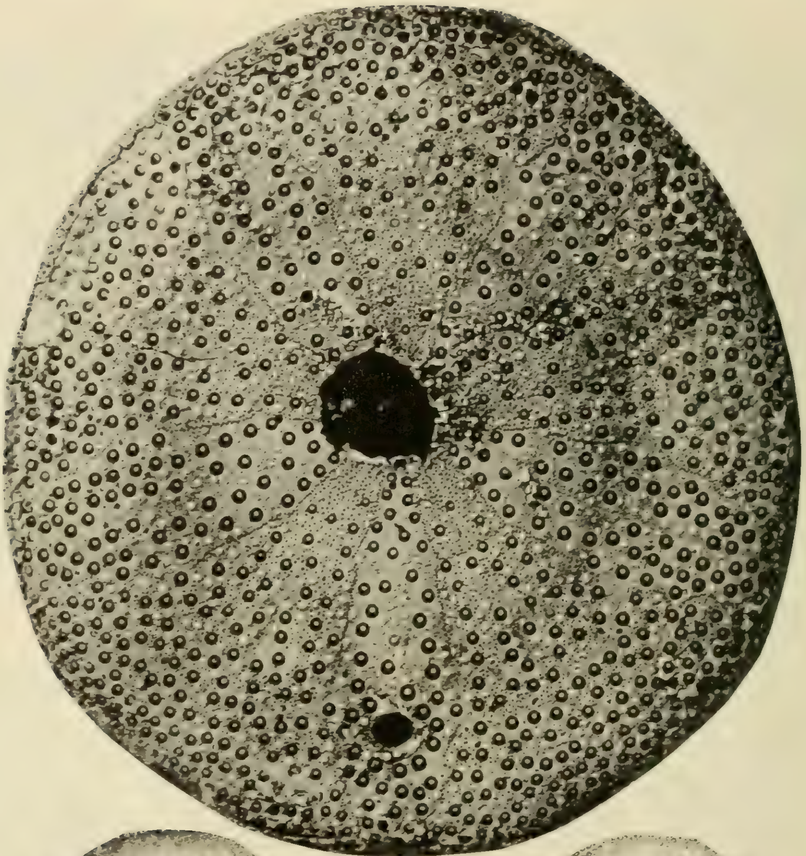

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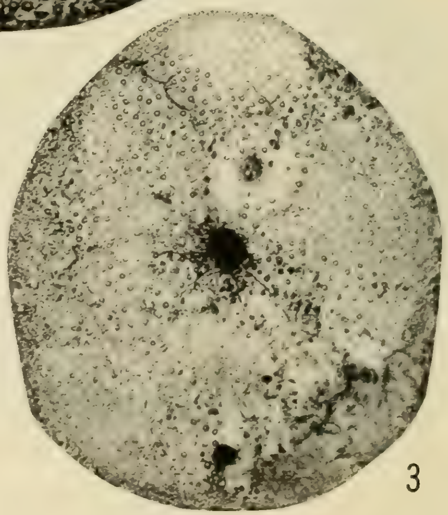

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1, *DURHAMELLA* CF. *D. FLORIDANA* (TWITCHELL)
2, 3, *DURHAMELLA OCALANA* (COOKE)

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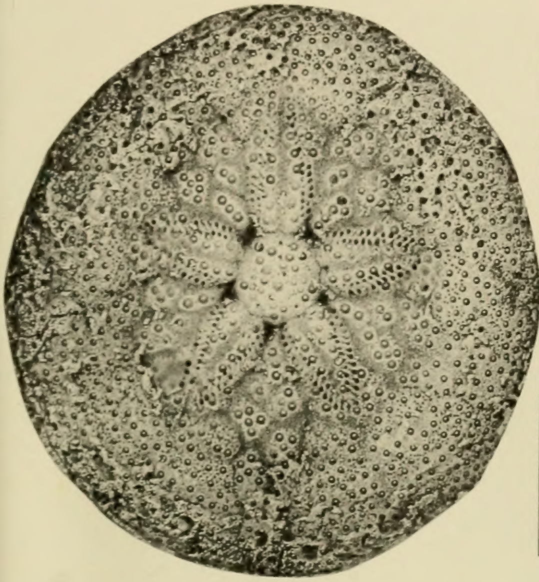

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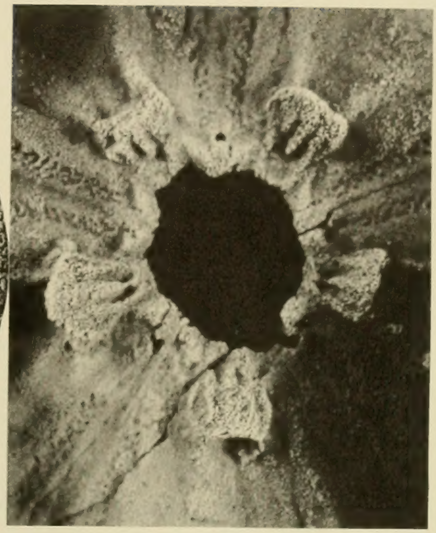

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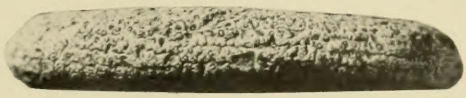

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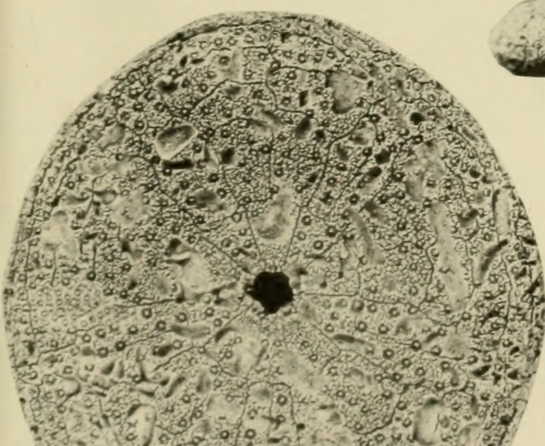

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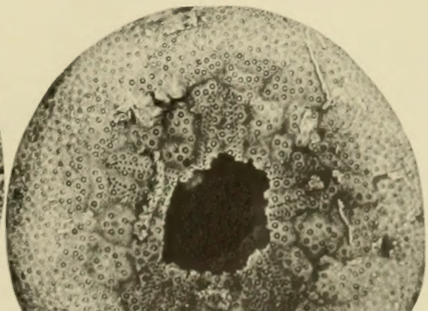

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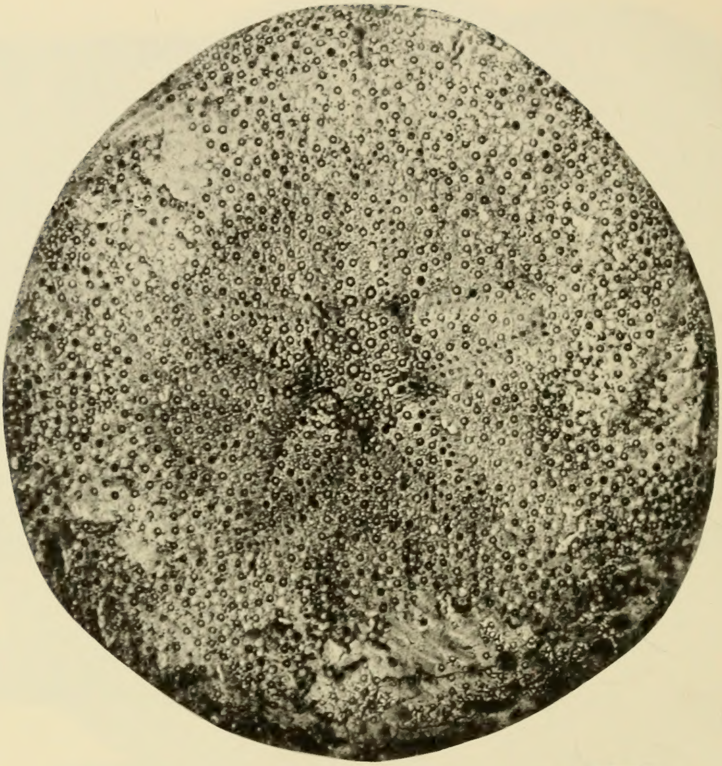
DURHAMELLA CF. *D. FLORIDANA* (TWITCHELL)

(SEE EXPLANATION OF PLATES AT END OF TEXT)



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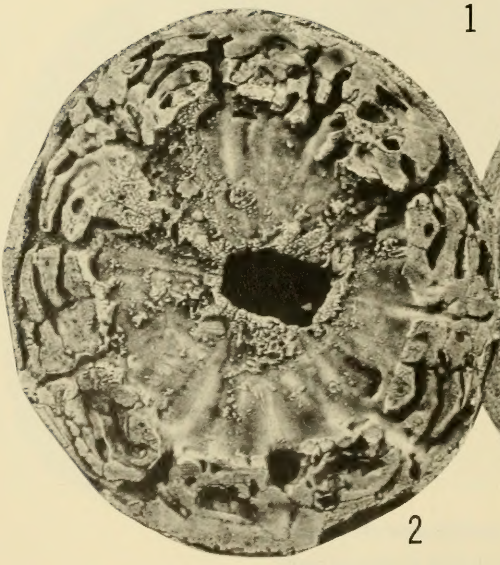

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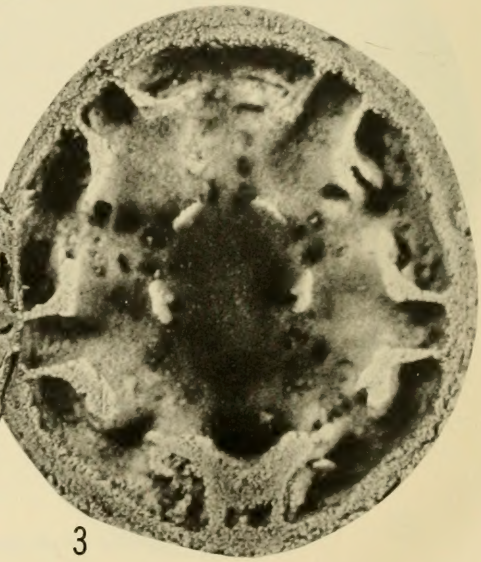

3

DURHAMELLA CF. *D. FLORIDANA* (TWITCHELL)

(SEE EXPLANATION OF PLATES AT END OF TEXT)